JOURNAL

OF THE

Department of Agriculture

OF

WESTERN AUSTRALIA.

Vol. 19. (Second Series) MARCH, 1942. No. 1.

The Carnarvon Tropical Reserve.

G. B. BARNETT, Tropical Adviser.

To further the development and ultimate settlement of the North-West of Western Australia, different potentialities are being exploited as the opportunity arises. The opening up of the Gascoyne settlement at Carnarvon is a case in point. As the settlement progressed it was realised that experiments would be needed to discover the plants suitable for this area as well as economical ways of raising and handling the resultant crops.

"Gascoyne" flood waters where wire netting is laid across the river bed to enable traffic to cross when the river is dry.

During 1938 a survey of the water possibilities of a block of land (Location 125) in the settlement, of the same type as those then being utilised for commercial crops, was made. This block was one of approximately 50 acres with a river frontage. Thirty acres of this were of a sandy loam carrying mainly wattles and minga bark with a smattering of river gum and blackheart trees. Of this area almost five acres have been cleared and graded. After ploughing, the ground had to

be irrigated, and a grader was used to bring about the required evenness of the six blocks. The accompanying illustration shows the grader at work in September, 1940, when this was done.

Grading the land preparatory to subdivision and planting.

There are over 800 feet of cement drains on the planted section of "The Tropical Reserve" being tested to ascertain the best type for local conditions.

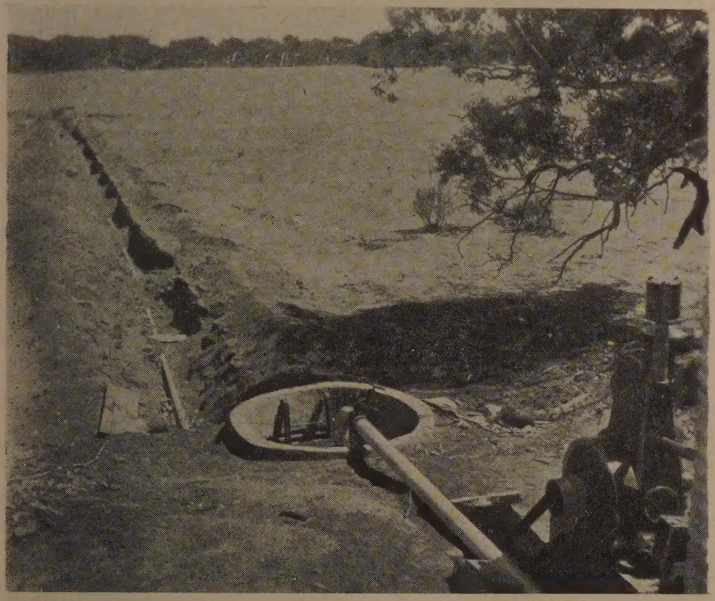
"Opening" banana rows 10 feet apart with a mouldboard plough.

The scope of investigation is a wide one, as not only irrigation and its problems are being studied, but also all tropical agriculture and its application in this district. As the country away from Carnarvon itself is mainly pastoral, studies are also being made of introduced fodders, grasses and other plant life to test their suitability to North-West conditions.

To investigate the banana growers' problems some 700 plants of 11 varieties have been planted out in furrows ten feet apart. The effects of preparing land one year prior to planting or otherwise are being observed as are the effects of deep and shallow ploughing of these soils prior to planting.

From the cultivation viewpoint notice is being taken of the results obtained from intense cultivation as well as those of deep, light and no cultivation. Attention is also being paid to the use of cover crops of different varieties.

To maintain adequate supplies of water it was necessary to instal an irrigation unit. As the surface waters of the Gascoyne River are, to say the least of it, transient, it was necessary to sink a cement cylinder in the sands of the dry river-bed to tap the waters below. The cylinder, 27 feet long and 5½ feet in diameter, was placed vertically in the river sands 250 feet out. From this the water was brought through a four-inch suction line by a 2½-inch centrifugal pump, driven by a 7-11 Diesel engine, to a pump well. From here it was pumped by the same engine to a 4-inch delivery pipe line of 150 feet to a spill pool.

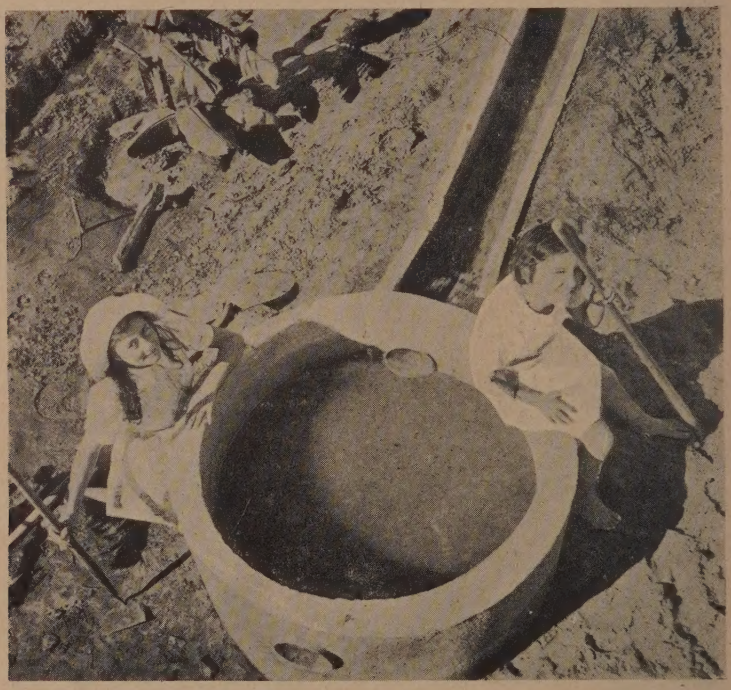


View of irrigation unit. Engine, suction line from river to well and part of 175-foot delivery line.

As it was necessary to conduct the experiments to aid all those working commercially in the district, provision has been made in the layout of the plots to test different types of spillways, of which there are 80 on the station. The spill pool at the delivery outlet is shown hereunder with the outlets to the main drains clearly visible. The capacity of this spillway is 20,000 gallons per hour.

Propagation plays an important part in the activities and this aspect is also being investigated. The various types of banana planting material such as corms, butts, suckers, peepers, etc., are being recorded and tests of various planting methods undertaken. Naturally, plant selection plays an important part, as do the stooling habits such as one, two or three followers. The economic factors from trashing, the effects of gouging and de-suckering and close and wide planting are further investigations being conducted.

Another duty of research being undertaken is the introduction and testing of varieties.



Spill pool at delivery outlets and outlets to main drains.

The utilisation of organic material in plant holes, and the advantage or otherwise of manuring during the first year of planting are further lines of research, as are the effects of monthly applications of sulphate of ammonia in irrigation waters. The economics of the number of applications of blood and bone fertilisers per annum (as well as studies on the use of nitrates, phosphate and potash) are being observed. Fertiliser trials (including the role played by nitrates, phosphates and potash) are being conducted and the results from liming soils are also being noted.

Not only are the different types of spillways for irrigation under test, but the various methods of application of irrigation waters are being closely studied.

This includes recording the results of heavy and light applications, long and short rows, and the economic factors involved. Winter irrigation is also receiving attention.

There are many problems affecting the fruit itself. Amongst those being studied are the results from bagging bunches, "Choke Throat," "Falling out," diseases and pests affecting plant, bunch and fruit. The removal of tassels, bottom hands and of the plant after harvesting offer further lines of investigation, as do the factors involved in the handling, transport and ripening room.

Other species of fruit are not being neglected. Varieties or strains of the pineapples, dates, citrus, macadamia, jack-fruit, avocado, papaya, passiflora and pecan nut have been collected for testing.

The fodders are also being investigated, not only from the plantation point of view, but also from that of the inland pastoralist. Varieties or strains of those at present under test are lucerne 9, millets 4, sorghums 7, grasses 9 and various fodder, shrubs and trees.

View of plantation, with main drain on right, six weeks after planting.

Subsidiary irrigation drains with spillways to banana rows. Rows 10 feet apart.

View of edge of plantation 10 months after planting.

Bean and tomato manurial plots with a background of plantains.

Vegetables are a pressing need under tropical conditions and are also an important commercial adjunct to the plantations. There are at present 23 varieties of strains of tomatoes under test at this reserve.

Carrots, swedes, onions, cabbages, cauliflowers, pumpkins, beans, peas, lettuces, melons, etc., are some of the vegetables receiving attention. Wherever possible plant life shown, adaptability to local conditions will be increased and distributed from here throughout the northern areas of the State.

"Stringy" Wool and Copper Deficiency in Western Australia.

H. W. Bennetts, Veterinary Pathologist.

1. INTRODUCTION.

"Stringy" wool is a valuable index of copper deficiency.

It appears to be the earliest and, frequently, most obvious sign, occurring even when the deficiency is not sufficiently severe to cause the more definite manifestation, of ataxia ("rickets") in lambs.

We have insufficient evidence yet to be sure that "stringiness" is invariably due to copper deficiency. On the other hand its entire absence in clips, predominantly of the merino type, can be taken as definite evidence that sheep are receiving an adequate supply of copper from the pasture. It should be realised, however, that many worm drenches contain copper; the regular administration of bluestone may, in some cases, provide a supplement adequate to prevent the appearance of signs of deficiency in sheep running on copper deficient pastures.

For many years, in this State, the occurrence of a characteristic type of wool, known to the trade as "stringy" or "slippery," has been associated with certain coastal and other areas now known to be copper deficient. More recently experimental work has shown that good quality merino wool, entirely free from

Figure 1.
"Stringy" wool Dandarragan.

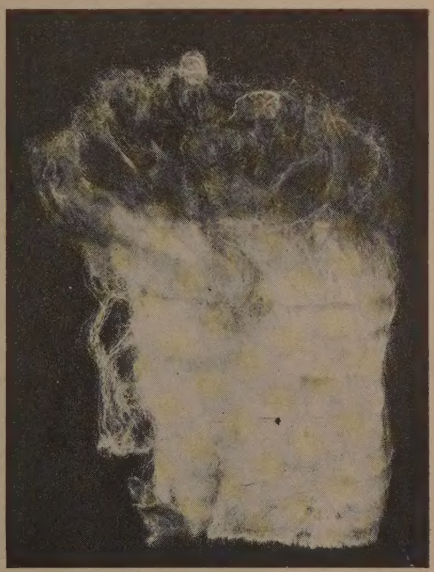


Figure 2.
"Stringy" wool from Mount Barker.
[Photo Govt. Print.]

"stringiness," can be grown on badly affected country with the aid of copper supplements. The results of their widespread use under practical farming conditions, during the past four years, have amply confirmed these experimental findings.

The distribution of "stringy" wool, throughout the State, and its association with other evidences of copper deficieney is being investigated further. It is hoped that this, together with other survey work, will increase our knowledge of the extent of copper deficient areas particularly those which are still only incipiently deficient. The practical value of this is obvious; "stringiness" lowers the commercial value of the clip and copper deficiency detrimentally affects the health and growth of the flock. The remedy is economical.

Investigations similar to those outlined above are being carried out also in South Australia where an identical defect known as "straight steely wool" (Anon., 1941) occurs in copper deficient areas.

The purpose of this article is to give a brief account of the facts already ascertained, in this State, about "stringy" wool. A preliminary account of other manifestations of copper deficiency was given in this "Journal" by Bennetts (1937). It is proposed to extend that information in a subsequent issue.

2. "STRINGY" WOOL, "SLIPPERY" WOOL, "STRAIGHT STEELY" WOOL.*

The occurrence of "stringy" wool in certain areas, now known to be copper deficient, was first recorded by Bennetts (1932). Its characteristics have been described by Bennetts and Beck (1942):—"After a few months sojourn on copper deficient country sheep exhibit characteristic wool changes. The wool becomes 'stringy,' that is, the crimp disappears and the wool has a limp, glassy and straight appearance. There is an absence of 'bulkiness.'" This brief description in association with illustrations (Figs. 1 and 2) may convey some idea of a wool defect well known to the trade.

RESULTS OF COPPER TREATMENT.

Figure 3.
Wool from sheep treated with copper. Note response to copper treatment shown in lower part of staple.
(See page 10.)

Figure 4.
Representative sample from a clip predominantly "stringy" prior to treatment under farm conditions.
[Photo Govt. Print.]

*Sometimes included also under the term "Doggy" wool.

During life a badly affected fleece presents obvious external defects. It appears very ragged and the wool having lost its normal robustness the fleece is very limp and floppy. This appearance is very noticeable in rainy weather when the wet fleece hangs down on each side of the body leaving a well defined wide parting along the open back. A change to healthy country or administration of copper supplement leads to a rapid and spectacular improvement in the external appearance of the animal, normal robustness of the fleece being realised within a very short period.

3. OCCURRENCE.

For many years the prevalence of "stringy" wool has characterised clips from the Gingin and Dandarragan districts, from an area west of Mt. Barker and from coastal country particularly in areas where animals develop "coast disease." One factor is common to all these areas, animals depastured thereon show evidences of copper deficiency and herbage, where analysed, is deficient in copper. In this connection the occurrence of ataxia in lambs, "stringy" wool and chemical evidence of low copper status of flocks have been established recently on coastal country in the vicinity of Broome.*

In the case of "coasty" country copper deficiency is complicated with a deficiency of cobalt which factor is responsible for the wasting, loss of appetite and weakness which characterise "coast disease." (Bennetts (1940)). There is no evidence of cobalt deficiency in other types of country on which "stringiness" occurs. Evans, cited by Bennetts & Beck (1942), has shown definitely that there is no cobalt deficiency at Gingin.

In the Busselton, Margaret River, Northcliffe area, shown by Bennetts *et al* (1939, 1941) to be very deficient in copper, few sheep are bred but "stringy" wool is known to occur.

During the past season in particular there has been a marked extension of the occurrence of "stringy" wool to light country as far inland as Yelbini, Doodlakine, Kondinin and Kukerin. This occurrence appears to be segregated particularly within the Corrigin soil region of Teakle (1940). Whether this, apparently recent development is a manifestation of an incipient copper deficiency, influenced possibly by recent seasonal conditions, has yet to be determined.

"Stringy" wool is most evident in fleeces of the merino breed where the loss of defined "character" is striking.

The defect is exhibited by sheep of either sex and of any age past the lamb stage.

It appears after sheep have been depastured for a few months on copper deficient pastures. A change to "sound" country or the use of copper supplements results in an early return to normal fleece growth.

There is some evidence that "stringiness," in common with other signs of copper deficiency, tends to be more marked during the green feed period and in "flush" seasons than during the dry feed months or during dry seasons when green feed is not so rank or so abundant.

Cultivation and pasture improvement in some way tends to accentuate the development of signs of copper deficiency in animals. These may be entirely absent in stock grazing similar unimproved areas. It appears probable that the same factors would affect the occurrence of "stringy" wool, also, but we have little direct evidence on this point.

*Observations made by Mr. L. Turner of Gingin, while classing wool in the Broome area led to this investigation.

4. "STRINGY" WOOL IN EXPERIMENTAL FLOCKS ON COPPER DEFICIENT COUNTRY.

During the years 1937 to 1939 experiments were carried out with groups of ewes maintained on a copper deficient property at Gingin for a second successive lambing season. Except in the latter season when cross-breds were used, ewes were principally of merino breed.

Different groups of from 12 to 25 ewes received copper supplements in the form of a regular drench, as a salt-copper lick or through pasture topdressed with copper compounds. Other groups were changed to "healthy" country during the in-lamb period. Other groups again served as controls and were given no copper or change of country.

The primary purpose of these experiments was to investigate the cause of enzootic ataxia ("rickets") of lambs by determining the influence of these experimental procedures on the occurrence of ataxia in the progeny. As, however, the clips from the experimental groups were examined by a professional wool classer the influence of treatments on wool growth was also assessed.

Following early indications from these experiments that "stringiness" was definitely associated with copper deficiency further experiments were carried out with stud merino sheep to determine specifically whether good quality merino wool could be grown on deficient pastures with the aid of copper supplements; the sheep available for the other experiments, referred to, had been selected from the farm flock where fat lamb breding was the main consideration. The whole series of experiments has been fully described by Bennetts and Beck (1942). The results may be summarised as follows:—

The work falls under two main heads—Observations in experimental groups at Gingin, and experiments with stud merino sheep selected for wool quality and transferred from Wagin to the same property at Gingin.

(i) *Observations in the Experimental Groups.*

Observations throughout the course of the experiments outlined previously, and the wool classer's report at the end of the seasons 1937 and 1938 indicated clearly that "stringy" fleeces characterised the control groups maintained without treatment on copper deficient country. On the other hand "stringiness" was almost entirely absent from clips from the groups which received copper supplements however administered. There was quite definite evidence that an adequate supplement would prevent the occurrence.

It was noted too that the effect of a change to healthy country and of copper treatment of deficient ewes was evident in the wool growth; the portion of the staple grown under these conditions showed normal character whereas wool grown previously or subsequently tended to be "stringy."†

Reference has been made to the abnormal external appearance of badly affected fleeces. Two severely copper deficient sheep from the control group in 1937, which were also very anaemic, responded in a remarkable manner to regular drenching with small amounts of copper (15 mg. daily) commencing early in June. Within fourteen days the floppy lifeless fleeces had assumed a normal external appearance: the portion of the staple representing the next few months' growth showed normal "character" whereas the earlier growth was exceedingly "stringy." (See fig. 3.)

†The definite response in wool growth to "change" country was pointed out to us by Mr. W. A. Inglis, W.A. manager of New Zealand and Australian Land Co., in 1928. The effect of the customary annual visit of "Yathroo" ewes to "Tootra" during the summer months to prevent ataxia was very evident in the wool staple.

At the 1938 shearing, in September, the weight yield and count of each fleece from the 20 ewes in each of four experimental groups were assessed and general remarks made on the wool from each group. The only significant differences were in wool quality. Fleeces from the control group tended to be "stringy" and tender whereas in the copper drenched and copper topdressed pasture groups "stringiness" was absent; the wool was sound and showed more body and condition. Results were not quite so clear cut in the group which had free acess to a copper-salt lick but the presence of some "stringiness" is ascribed to the undoubted marked variation in individual consumption of lick.

(*ii.*) *Experiments with Merino Sheep Selected for Wool Quality.*

The above observations that "stringy" wool is associated with copper deficiency and can be eliminated by adequate supplementation were further confirmed by the following experiment:—For the purpose six animals (cull Merino rams), selected for high wool quality, were provided. They were received at Gingin on 30th March, 1938, and were paired on wool type and randomised into two groups of three, one to receive copper, the other to serve as controls.

The sheep in the copper group received a drench of copper sulphate thrice weekly, the copper intake being equivalent to 15 mg. daily. The supplement was administered from 5th May until 1st September, 1938. The sheep were shorn and fleeces classed on 13th September. Copper treatment, discontinued on 1st September, 1938, was recommended on 4th March, 1939 and continued until 23rd August, 1939, the dose and method of administration being as in 1938.

The sheep were again shorn on 15th September, 1939, and fleeces classed.

The results obtained each season were strictly comparable and confirmatory. The details of fleece examinations in 1938 are shown in the following table:

WOOL YIELDS OF CONTROL AND COPPER TREATED MERINO SHEEP, 1938.

Sheep No.	Weight (lb.).				Spinning Count.	Clean Scoured Yield.
	Belly.	Pieces.	Fleece.	Total.		
						%
Controls—						
A25	1	1½	11	13½	64	48
A21	1	1	10	12	64	48
A23	1	¾	10	11¾	64	48
Copper Drenched—						
A24	1½	1½	10	12½	60–64	46
A20	1	1½	12½	15	60–64	46
A22	1	1½	11	13½	60–64	46

The report of the classer was as follows:—

"Copper-drenched group have definitely better grown fleeces with more bulk and heavier condition. They are slightly broader in quality and there is a complete absence of 'stringiness' whereas in the control group 'stringiness' is very marked in one fleece (A23) and noticeable in the others."

The results of copper supplementation on wool quality are undoubtedly significant: the somewhat greater weight of wool from the copper-treated group is of doubtful significance.

5. CONTROL.

Experimental evidence and results under practical farming conditions clearly indicate that the provision of adequate copper supplements will control the occurrence of "stringy" wool. The measures adopted are identical with those previously recommended for the control of copper deficiency in sheep (*vide* this Journal (4 : 247 and 17 : 41).

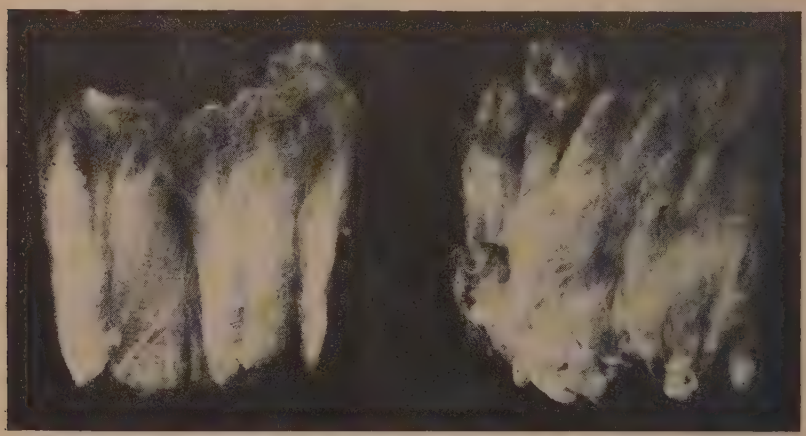


Figure 5.
Fleeces from sheep paired on wool type. Left copper treated (A24). Right no treatment (A25). (See page 11.)
[Photo Govt. Print.]

Copper may be administered in lick form, as a topdressing to pastures or if other measures are impracticable by drenching at frequent intervals. The choice of method depends on local circumstances and advice can be obtained on application to this Department.

It may be stated, however, that the lick generally recommended is a salt lick containing from ¼ to ½ per cent. bluestone, the concentration being adjusted according to rate of consumption. An average weekly consumption per head of 2 oz. of the former or 1 oz. of the latter is adequate.

For topdressing copper is applied as bluestone at the rate of 5 to 10 lb. per acre mixed with super. Copper in other forms such as copper ore is also effective.

6. SUMMARY.

The characteristics, distribution and control of "stringy" wool have been discussed.

"Stringy" wool is a good index of copper deficiency. Its entire absence, particularly in flocks predominantly of the merino breed, indicates that the pastures contain sufficient copper to supply the needs of stock. On the other hand the presence of "stringiness" generally, if not always, indicates copper deficiency.

There is some evidence that the occurrence of "stringy" wool may be of value in defining areas incipiently deficient in copper.

A survey of the distribution of "stringy" wool in this State in relation to other evidence of copper deficiency is being carried out.

REFERENCES.

Anon (1941): *J. Dept. Agric. S. Aust.*, 44 : 299.
Bennetts, H. W. (1932): *Aust. Vet. J.*, 8 : 137.
Bennetts, H. W. (1941): *J. Dept. Agric. West. Aust.*, 17 : 41.
Bennetts, H. W., and Beck, A. B. (1942): *Bull. Coun. Sci. Industr. Res.*, In Press.
Bennetts, H. W., Beck, A. B., Harley, R., and Evans, S. T. (1941): *Aust. Vet. J.*, 17 : 85.
Bennetts, H. W., and Hall, H. T. B. (1939): *Aust. Vet. J.*, 15: 152.
Teakle, L. J. H. (1937-38): *J. Roy. Soc. West. Aust.*, 24 : 123.

ACKNOWLEDGMENTS.

The assistance afforded by Dalgety & Co., Ltd., Elder, Smith & Co., Ltd., Goldsbrough Mort & Co., Ltd., and Westralian Farmers, Ltd., is gratefully acknowledged; we are indebted particularly to Messrs. L. G. Cox and D. S. Scott of Elder Smith & Co., Ltd., and to Mr. G. Smith of Westralian Farmers, Ltd. The co-operation of Mr. F. A. Wedge of Gingin greatly facilitated the experimental work and the active interest of Mr. A. M. Stewart, B.Sc.Ag. of the University of Western Australia was much appreciated.

Some Insect Pests of Military Camps.

By C. F. H. Jenkins, Government Entomologist.

INTRODUCTION.

Insects have always occupied an important place in man's economy, even in peace time, but under war conditions these creatures are apt to play an even more important role than usual.

The subject of insects and war can be approached from several angles. Firstly may be considered those insects which affect directly the health and efficiency of soldiers; secondly those which multiply abnormally on the home front due to disorganised trade conditions, and thirdly those which, by their remarkable achievements in the sphere of mimicry and protective colouration have shown the guiding principles which should be adopted in that important technique of modern war, camouflage. The insects dealt with in this article fall mainly into the first category, and comprise those of most interest to the soldier. Although one or two of the pests dealt with are not true insects, for convenience they have been included in this paper.

In a military camp where large numbers of men are gathered together for a considerable period of time, there is always a danger of outbreaks of various insect and allied pests, and apart from the irritation, both physical and mental, which may accompany these outbreaks, there is the far greater danger of disease.

The House Fly (*Musca domestica* L.).

There is no more widely known pest or disease carrier than the house fly. Volumes have been written dealing with its habits and control, but it still remains one of the most important problems of the medical entomologist.

RELATION TO DISEASE.

The house fly exemplifies one of the simplest types of disease transmission by insects, the role of the insect being merely that of a mechanical carrier. Flies infest and breed in all manner of refuse such as garbage, damp lawn clippings, human excreta, and especially horse manure. Under such circumstances they have every opportunity of coming in contact with disease contaminated material of all kinds, tiny portions of which may be either swallowed or carried about adhering to the hairs of the legs and body. In conjunction with the already described habits of the fly must be remembered its keen appreciation of foodstuffs, such as jam and sugar. It can then be seen how easily a single fly is able to contaminate food or drink merely by settling thereon.

Fig. 1.
House Fly (enlarged).
(After Gibson & Twinn.)

The habit of regurgitating a drop of fluid in order to moisten certain foods offers an additional means of contamination since viable bacteria are known to have occurred in "fly specks." In order to emphasise the potentialities of the house fly as a disease carrier, may be quoted the fact that a single insect has been known to carry well over six million bacteria.

Amongst the diseases carried by the house fly are typhoid, cholera, various types of dysentry and ophthalmia and tuberculosis. No further propaganda than the above list should be required for an anti-fly campaign, and yet only too often the matter is given but scant attention.

Under the well regulated sanitation of modern cities the menace of typhoid, cholera, etc., has greatly diminished, but where facilities are more primitive, as under active service conditions or in bombarded cities, the most stringent sanitary precautions must be enforced to prevent outbreaks of disease.

Before the necessary precautions can be taken against any pest, however, an accurate knowledge of the life history and habits of the creature concerned is essential, and so a brief summary of the natural economy of the house fly will be given.

LIFE HISTORY.

The most important breeding medium of the house fly, as already stated, is horse manure. It has been estimated that 95 per cent. of the fly population emanates from this source. Infested manure heaps have been known to average 685 maggots to the pound.

Fig. 2.
The House Fly—1, eggs; 2, larvae; 3, pupae.
(After Gibson & Twinn.)

A single fly may lay from 5-20 batches of eggs, each batch containing from 75-150 eggs. The elongated light-coloured eggs measure about 1/25 inch in length and take from 8-24 hours to hatch under optimum conditions. The small white maggot grows rapidly and passes through what are known as instars or stages, each stage being marked by a moulting or shedding of the skin and an increase in size.

When fully grown the maggot passes through an inactive prepupal stage, during which no feeding is done and after which it buries itself in the soil to pupate.

The larval stage may cover from 3-5 days in favourable weather and pupation time an equal period.

From the figures quoted it will be evident that the house fly can complete its life cycle in a little over a week. A further period of from 7-14 days, however, must elapse before a female can lay eggs so that the interval between successive generations is about three weeks.

It must be clearly understood that the time taken to complete any particular stage may be greatly protracted by cold or adverse weather conditions. The larval stage, for instance, may extend over a month or more under certain circumstances, consequently an adult fly can emerge in a week or several months from the time of egg laying, according to whether conditions are favourable or otherwise.

If these particulars are kept in mind the old question—"Where do the flies go in the winter time?" offers little difficulty. Much of the population dies out if conditions are particularly adverse, but a portion survives in various stages and is able to bring about a rapid build up of numbers when a favourable time comes.

CONTROL.

As always, "Prevention is better than cure" and strict sanitation is the major factor in controlling the house fly menace.

Horse Manure.

For the first three days horse manure is especially attractive to flies, but gradually receives less attention as it ages and dries. Wherever possible manure should be collected daily before maximum egg deposition has occurred, and should be disposed of in such a manner as to render it unsuitable for further fly development. Various methods are adopted to achieve this purpose, and the principal measures will be briefly outlined.

Compacting Manure.—When fresh manure is tightly packed considerable heat is generated by the process of fermentation and the main bulk of the pile is rendered quite unsuitable for fly breeding. Only the outside material is cool enough for the development of eggs and maggots, and suitable chemical treatment will render even this section barren. The main essentials to be observed in stacking manure are to see that the heap is thoroughly compacted and that the sides of the pile are kept vertical.

A simple method of protecting fresh manure is to stack it in a line and cover the heap with a few inches of packed soil, leaving exposed only the face where the loading is taking place.

Another system based upon recommendations made by Fay is to pile the manure into compact stacks with sides as vertical as possible and dig a trench six inches by six inches along each side. If the top of the manure is covered with iron or tarred paper and the air temperature rises to 80° F. for a total period of five hours, all maggots in the manure will be killed. If the cover is removed after five days the heap will no longer be suitable for breeding. Any larvæ attempting to leave the hot stack will be drowned in the liquid drained into the surrounding trench.

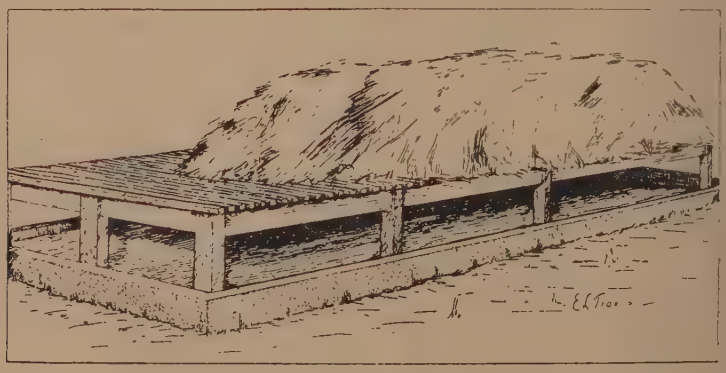


Fig. 3.
A trap for house-fly maggots.
(From U.S. Dept. Agr.)

Maggot Traps.—Various types of maggot traps have been devised, based upon the knowledge that mature maggots tend to migrate a short distance from the manure heap to burrow into the soil and pupate. They are mainly a modification of Fay's stack method described above. The manure is either stacked on a raised grating or slatted platform surmounting a trough of water or piled into a wire pen with a concrete floor and surrounded by a six-inch ditch containing water. In each case migrating maggots fall into the water and are drowned.

Incineration.—This is the most effective way of dealing with any refuse, but it is not always the most practicable or economical. The method is sometimes used, however, in military camps when it is impossible to dispose of manure for agricultural purposes. The manure may be burnt in pits or special types of incinerators.

Spreading Manure.—During hot weather manure may be scattered thinly over paddocks so as to dry quickly and be thus rendered useless as a fly breeding medium. Under Western Australian summer conditions this method would be quite effective, but care must be taken lest large pockets of manure more than about an inch deep are left to act as breeding foci. Following this principle manure is sometimes used to surface sand roads and tracks and providing the dressing is applied thinly enough this method of disposal is satisfactory.

Chemical Treatment.—Borax is widely recommended for treating manure and garbage for the prevention of fly trouble. One ounce of borax to a cubic foot of manure will kill 90 per cent. or more of fly maggots and prevent further breeding. In experiments carried out by the New Jersey Experiment Station the stablemen were supplied with water cans and instructed to treat the daily manure output of each horse (about 1½ cubic feet) with 2½ gallons of borax solution. Manure treated in this way is injurious to plants under some circumstances, but as far as is known can be safely used up to 15 tons to the acre where borax is used at not more than 1 lb. to 16 cubic feet.

Creosote Oil.—This is a strong repellent of many insects and was used with success during the World War (Herms, 1939) for treating dead bodies and manure. Applied as a fine spray over the daily additions to the manure heap, one gallon to the ton proved effective.

Fig. 4.
Garbage can with fly trap attached.
(After Herms.)

Garbage and Food Waste.

Flies will breed in practically any decomposing organic matter, consequently garbage and food waste should never be carelessly exposed to fly attack. Fly-proof containers should be used for temporary storage and the material should finally be disposed of by burning or deep burial after treatment with borax or other larvicide. Shallow burial alone may be quite ineffective, owing to the fact that flies are capable of penetrating two feet or more of loose soil.

A rubbish bin to be recommended combines garbage can and fly-trap as illustrated in Fig. 4.

Human Fæces and Sewage Beds.

Every effort should be made to prevent flies having access to human excreta. The medium is not only a dangerous one from a breeding point of view, but its potentialities from the disease dispersal aspect are self evident.

Typhoid, cholera, and dysentery are only three examples of fly-borne diseases which have scourged military and mining camps throughout history and the incidence of these diseases is closely bound up with fly control.

Under normal peace-time conditions municipal bodies, sanitary contractors, etc., deal effectively with fæces disposal, but under military conditions all modern facilities cannot always be available. It is then that particular care must be taken. Material should be protected from flies wherever possible and treated with suitable chemicals (*vide* "Treatment of Horse Manure").

Where trench latrines are used they should be as deep as possible and all material should be treated before burying. The latter operation should be carefully carried out because, as already stated, flies are capable of coming through considerable depths of soil. Unless the hole is deep and the soil well tamped down, fly emergence may subsequently take place, and be the cause of an apparently inexplicable infestation.

Sewage treatment plants sometimes breed many flies in the sludge beds at the end of the process. Chemical treatment is not generally favoured where modifications of procedure can be adopted to prevent infestation, but spraying with ½lb. pure carbolic acid plus 40lbs. caustic soda to 60 gallons of water has been effectively used to stop fly breeding. Creosote oil could doubtless be used in the same direction.

Combating Adult Flies.

Fly Screens.—Despite precautions there will always be a certain number of adult flies to contend against. Fly wire screens for doors and windows of permanent dwellings are effective if carefully fitted, and combined with the use of fly-proof safes and covers for all food should prevent much danger of food contamination.

Fly Sprays.—Kerosene-Pyrethrum* spray will be found very useful against almost all the insects mentioned in this article. It has a fumigatory as well as a contact action and so is most effective in a closed room. Under exposed conditions direct contact with the insect is necessary.

Fly Poisons.—A poison widely recommended may be prepared as follows:—

Commercial formalin	1 fluid oz. (2 tablespoons)
Filtered lime water	½ pint
Sugar	½ ounce
Water to make	1 pint

The preparation may be used in shallow dishes or saucers in which are placed pieces of bread, sponge, blotting paper or other absorbent material.

Sodium arsenite solution at one per cent. concentration with the addition of 12 per cent. glycerine and five per cent. sugar was used effectively during the Palestine campaign, 1914-18 (Davidson, 1918).

Fly Traps.—The judicious disposal of fly traps about a camp may help to keep numbers down. The traps should be baited with some attractive material and placed in sheltered situations where the flies have been noticed to gather.

Sweetened milk, thin treacle syrup or some similar material makes a very suitable lure for house fly traps. The type of trap may vary, but in the main they are some form of wire cage into which opens a wire cone with a small hole at the apex by which the fly enters but through which it has difficulty in finding its way out. The "West Australian" blowfly trap† has proved satisfactory in local cavalry camps and so can be recommended.

**Vide* appendix. †Details of the manufacture of this trap are available from the West Aust. Dept. Agric. Leaflet 647.

Traps should be emptied regularly and not allowed to become more than half full of flies, otherwise their efficiency will become impaired.

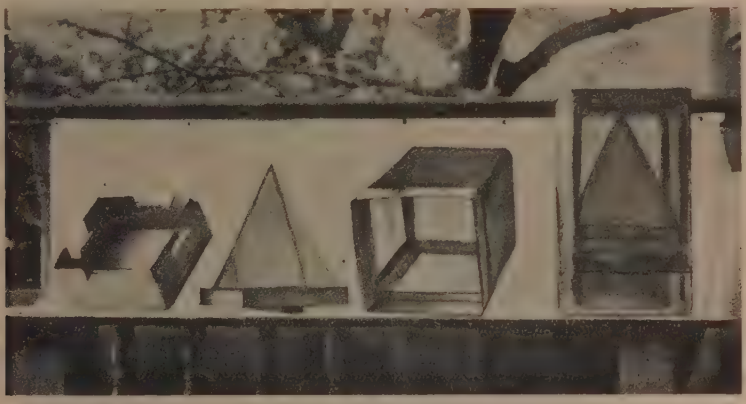


Fig. 5.

West Australian Fly Trap (showing sections of same).
1, Reservoir; 2, Cone; 3, Fly Chamber; 4, Complete Trap.

Fly Papers.—The mixture used in the preparation of the "tangle foot" type of fly papers and fly wires is prepared from the following:—

Resin	2 pounds.
Castor Oil	1 pint.

The ingredients are heated together to the consistency of honey and then smeared on paper or wires to be hung from the roof or placed in other suitable spots.

Blowflies (*Calliphoridae*).

These flies can readily be distinguished from house flies by their larger size and noisy habits. There are several species occurring locally belonging to two types, the brown blowflies and the blue bottles or green bottles.

LIFE HISTORY.

The life history of the blowfly is comparable to that of the house fly but the former favours carrion rather than general garbage as its breeding medium. Under certain conditions, as in the case of sheep or neglected wounds, live flesh may be struck, but multiplication from such sources would not be important to the soldier.

CONTROL.

As in the case of the house fly, careful disposal of all suitable breeding material is the first essential. Carcases of animals should be incinerated or suitably poisoned. Simply burying is rarely satisfactory as blowflies have been known to penetrate 10 feet of loose soil. Dusting carcases with powdered arsenic or sodium fluoride diluted with equal parts of inert dust effectively prevents the development of maggots.

Traps.—As in the case of the house fly the "West Australian" blowfly trap may be used with advantage but a meat bait must be used. Liver covered with a sodium sulphide solution (two ozs. to the gallon) is very attractive. Baits should always be kept moist, as they remain attractive longer in this condition.

Fig. 6.
Blowfly (from *Health Bull.*, Vict.).

The Bush Fly (*Musca vetutissimi* Walk.).

Although very similar in appearance to the house fly, the bush fly seldom enters houses and so is not so likely to be implicated in the contamination of food. It is this species which swarms about persons and animals out of doors and which carries the infection commonly known as "bung-eye."

It is a less prolific breeder than the house fly, but like the latter breeds in fresh cow and horse dung and decaying vegetable matter.

The Stable Fly (*Stomoxys calcitrans* Fabre).

Like the bush fly, this species bears a close general resemblance to the house fly, but can be immediately distinguished by its biting mouthparts. The stable fly is provided with a rigid proboscis suitable for piercing the skin of animals, and although it is primarily a pest of livestock the fly frequently turns its attention to man.

Its life history resembles broadly that of the house fly, but it has probably a less extensive range of breeding media. Stable litter impregnated with manure and urine is particularly attractive and should never be allowed to accumulate.

In general, the measures adopted against the house fly will prove effective against this pest. Although by no means such an important disease carrier as the house fly, the stable fly is said to be capable of carrying several diseases, including anthrax and poliomyletis.

Fig. 7.
The Stable Fly (from *Health Bull.*, Vict.).

The following spray formulae have been devised to protect animals from fly annoyance (Herms 1939):—

I.	Petroleum oil		50 c.c.
	Unsolfonated residue	90	
	Viscosity	97	
	Pine oil steam distilled		50 c.c.
	Sp. Gr.	9377	
	B.P.	194-217	
	color	I.N.P.A.	
	Pyrethrum extract (19-1)		50 c.c.
	Diglycol oleate		28.9

Dilute slowly with eight parts of water, agitating vigorously.

II.	Creosote	1 part
	Turpentine	32 parts
	Olive oil	80 parts
III.	Fish oil	1 gallon
	Oil of pine tar	2 ozs.
	Oil of Pennyroyal	2 ozs.

Sand Flies (*Phlebotomus* spp. and *Ceratopogon* spp.).

The true sand flies belonging to the genus *Phlebotomus* are capable of transmitting certain human diseases such as sandfly fever but fortunately this group has not been recorded from Western Australia.

The so-called sand fly, often annoying in the late winter months, is a species of midge (*Ceratopogon* sp.). It is a very small black insect so inconspicuous that it is usually felt before it is seen. The bite is particularly irritating to certain people but as far as is known no diseases are borne by this midge. It breeds in moist localities and so far as possible such situations should be avoided for camping sites during the "sand fly" season.

Mosquitoes.

Few other insects can compare with mosquitoes as pests of man and domestic animals and on this account they have long received the attention of entomologists and the medical profession.

Malaria, the most important insect-borne disease in existence, has actually played an important part in the moulding of history. The disease was believed to have existed in ancient Egypt and its prevalence is reputed to have had much to do with the decline of the Grecian Empire. The armies of Alexander the Great are said to have helped spread the disease, thus raising a point very pertinent to present conditions.

TYPES OF MOSQUITOES.

In Australia are to be found a large number of different species of mosquitoes, but they may be divided into two main groups sometimes known as the Culicines and the Anophelines.

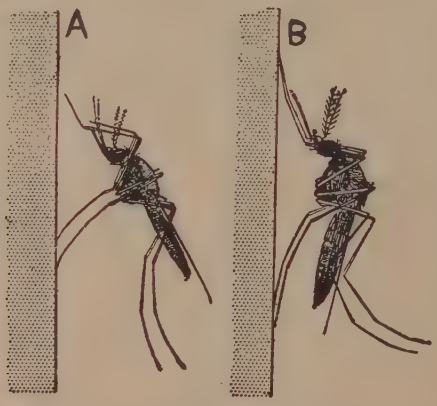


Fig. 8.
Sitting postures adopted by mosquitoes.
A. Anopheles. B. Culex.
(After Edwards.)

In the Culicine group are placed the common brown mosquito (*Culex*) and the white banded mosquito (*Aedes*), and in the second group the malarial carrying members of the genus *Anopheles*.

The two groups can be readily distinguished from the different resting positions taken up by both the adults and the wrigglers or larvæ. The accompanying illustration shows how the Anopheles holds its body at a steep angle to the supporting plane whereas Culex carries the body more or less parallel to the surface.

With regard to the wrigglers, observation shows that Culex larvæ when resting or breathing hang almost vertically from the water surface film, whereas the Anopheline wrigglers lie almost parallel to it.

RELATION TO DISEASE.

Although a number of different diseases are transmitted by mosquitoes, each disease is carried by a particular species. For instance, members of the genus *Anopheles* are the intermediate host for the malaria parasites, *Culex fatigans* Wied. carries the filarial nematode and *Aedes ægypti* Linn., may transmit yellow fever or dengue fever.

So far mosquito-borne diseases have been kept well in subjection in Australia. By stringent quarantine measures the yellow fever virus has not been allowed to become established and malaria is only endemic in certain northern areas. Dengue fever and filariasis are also associated with the more tropical portions of the continent.

What must be borne in mind, however, is that the host insects of all these diseases are widespread in Australia and that the potential menace of diseases becoming established due to influxes of infected persons is ever present and particularly acute during war time.

In addition to the disease aspect of mosquito control, there is also the less important but probably more popularly recognised nuisance point of view to be considered.

LIFE HISTORY.

Before any control campaign can be successfully carried out against any insect a knowledge of the life history and habits of the creature is essential.

Different species of mosquitoes have different habits. Some breed in salt water and rock holes by the sea shore; some prefer stagnant water; others gently flowing streams, and others again, the small accumulations of rain water caught in tree knot-holes and hollows. In all cases water is essential and the general type of life history is the same.

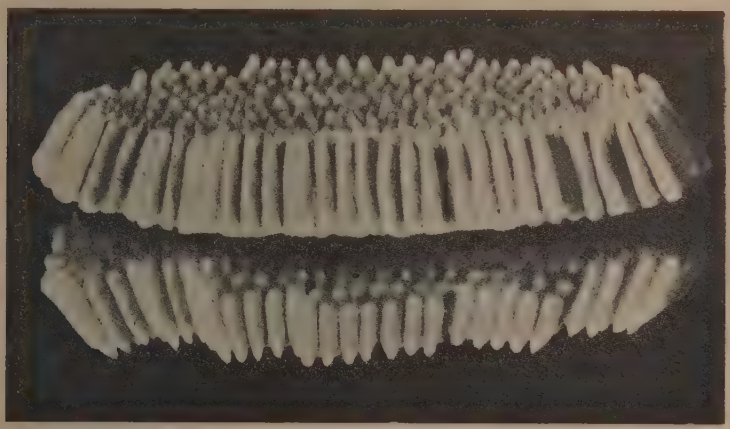


Fig. 9.

Mosquito egg raft floating on water. About 60 times natural size.
(From U.S. Dept Agr.)

In the case of *Culex*, which will be taken as typical, the eggs are laid in floating clusters or rafts of two to three hundred eggs. Hatching occurs in a few days and the larvæ or wrigglers emerge. The wriggler stage occupies three or four days and during this time the insect feeds upon minute particles in the water of vegetable and animal origin. Although apparently quite at home in the water, mosquito wrigglers are compelled to come to the surface to breathe. The air is taken in by means of the respiratory siphon or tube, situated at the hind end of the body. The opening of this tube is surrounded with hairs which are spread out on the surface of the water and help to support the larva. It is a knowledge of this habit which makes it possible to control mosquitoes by the use of kerosene and oil films.

After four or five days, during which time the larvæ moult four times, the pupal stage follows. The now comma-shaped insect is still active, but on account of its buoyancy always tends to float in an upright position to the surface. Two breathing tubes on either side of the head of the comma now take over the duties of the tail siphon of the wriggler.

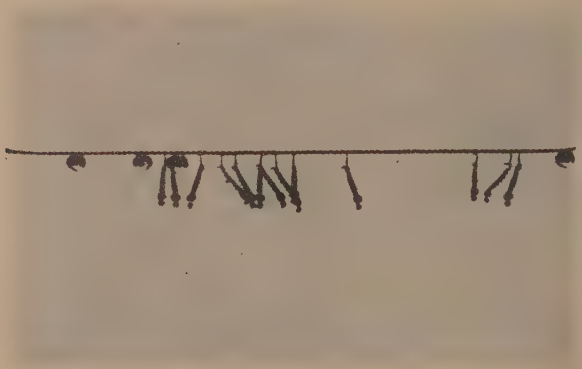


Fig. 10.

Mosquito wrigglers. Larvae and pupae as they appear at the surface of the water to get air.

(From Conn. Exp. St. Rpt.)

The pupal stage may only last one or two days, so that under favourable weather conditions the period from egg to adult may only require about a week. Of course, the stages in the life history will be greatly lengthened under unsuitable weather conditions and the eggs of some species are able to withstand frost or desiccation for several weeks according to the type of climate to which they are exposed. If in addition to this it is recollected that the adult yellow fever mosquito has been kept in captivity for over five months there will be no mystery as to how mosquitoes carry over severe winters or prolonged droughts.

CONTROL.

As has been emphasised already in this article the first control measures should be levelled at the breeding haunts of any pest. It has been shown that water is essential for the breeding of mosquitoes and so any infested locality should be carefully examined for suitable breeding grounds. No catchment of water should be considered too small or unlikely; stray tins, discarded bottles, liquid manure barrels, tanks, sluggish drains and swamps can all contribute materially to the mosquito population of their neighbourhood. In many cases the source of trouble can be easily removed or again it may involve the digging of drains, the deepening of swamps or the screening of cisterns and tanks. Where the breeding source cannot be removed or where the shallows of lakes and swamps cannot be deepened so as to enable the general movement and wave action to render the water unsuitable for mosquito breeding, chemical treatment may be used.

Larvicides.—Oil films: The most commonly used larvicide is kerosene, but various types of oil may be used to make a film on the water surface. The quantity of kerosene required is about one ounce (two tablespoonfuls) to 15 square feet, or 50 gallons to the acre. Another preparation requiring much less oil consists of a kerosene-pyrethrum extract emulsified with a gallon of water containing

10 ounces of liquid 40 per cent. potash soap. A gallon of this emulsion mixed with nine gallons of water is used for spraying at 50 gallons per acre (Hogan, 1940).

Paris Green.—Paris Green dusted on the water at the rate of one ounce to 150 square yards acts as an effective stomach poison. The dust is relatively insoluble and floats on or near the surface and so is ingested by the feeding wrigglers. For economy and ease of application the poison is usually mixed with some inert carrier.

Repellents.—A number of essential oils are relatively repellent to mosquitoes and one of the most widely used is citronella. The following mixture is also widely recommended:—

Vaseline	.. ..	2 ounces.
Citronella Oil	.. ..	½ „
Spirits of Camphor	..	¼ „
Cedar Wood Oil	..	¼ „

The preparation should be spread on the exposed portions of the body.

Screening.—In disease-infected countries wire gauze and mosquito net screens are habitually used to exclude insects from dwellings and from sleeping persons, and if carefully arranged they are an important factor in disease control.

Lice.

None of the foregoing insects can truly be described as a parasite of man, but there are several in this category with which the soldier has to contend. The most important of these are the various forms of lice. The commonest, the *body louse,* as well as causing considerable irritation, is the carrier of such fatal diseases as typhus, relapsing fever and trench fever.

RELATION TO DISEASE.

Typhus, also known as Brill's disease, occurs in two forms and both are transmitted from man to man by lice. In the case of the American form or murine typhus, the disease is carried over by rats and transmitted to man by the bite of the rat flea. The European or classical typhus is sometimes known as "war fever" and during the period 1914-18, when typhus was at its height, people died at the rate of 9,000 per day in Serbia.

Infection occurs either through the bite of the louse or through infected lice being crushed and scratched into the skin. In the case of relapsing fever and trench fever it is believed that infection is mainly, if not entirely caused by scratching and crushing infected lice.

The Body Louse (*Pediculus humanus corporis* De Geer).

Often known as the cootie or greyback, the body louse is greyish in colour and about ⅛-inch in length. It inhabits the clothing, more especially those parts which come in more or less constant and close contact with the body, such as the neck, armpits, waist and fork of the trousers.

LIFE HISTORY.

A female louse may lay up to 300 eggs which are deposited for preference on fibres along the seams of clothing, especially trousers, but coarse body hairs may also be involved. Hatching occurs in about six days and the nymphs may reach maturity in about another 10 days. Lice will not live any great length of time away from the host, a starvation period of probably 10 days (Herms, 1939) being fatal. The normal life span seldom exceeds about 40 days.

CONTROL.

The first aim should be to avoid becoming lousy by shunning contact with lousy persons, being scrupulously careful about personal cleanliness and bathing as often as opportunity offers. Should such precautions fail or be impracticable more direct action against the lice themselves will be necessary.

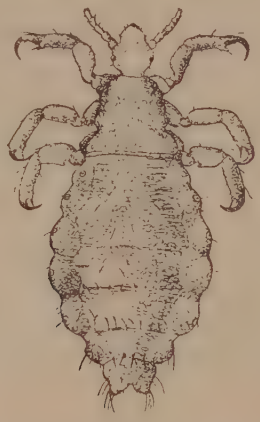


Fig. 11.
The Body Louse (enlarged).
(After Patton & Cragg.)

Heat Treatment.

Dry Heat.—Ironing clothes with a hot iron, paying special attention to the seams, singeing or baking in an oven has been widely used. For dry clothes placed in a chamber or oven the temperature necessary to kill both adults and eggs or nits is 140 deg. F. for 20 minutes. Immersion for 20 minutes in water which does not fall below 140 deg. F. will be effective providing the water is allowed to penetrate the bundles easily.

Steam Sterilisation.—Where facilities are available steam treatment is very effective. The chamber should be kept at about 12-15 inch vacuum for five minutes and then charged with steam until 15-20 lbs. pressure has been produced. The pressure should be maintained for 15 minutes.

Fumigation.

A gas-tight chamber or box may be used for this treatment and a variety of chemicals used. In some cases fumigants do not give guaranteed control against eggs, but are very effective against adults.

Carbon-bisulphide.—This fumigant may be used at the rate of 4-8 lbs. per thousand cubic feet of space, the heavier dosage being used if leakage is occurring. In order to penetrate to all parts of clothing the fumigation must be maintained for about 12 hours.

Chloropicrin.—This is a particularly effective fumigant. It has great penetrating powers and at the rate of 4 c.c. to the cubic foot kills all adults in fifteen minutes and eggs in half an hour. In order to kill eggs in 30 minutes a suitable temperature is necessary so as to ensure the rapid evaporation of the chloropicrin. This may be achieved during cool weather by packing one litre flasks of water at 89 deg. C. amongst the clothes at the rate of a flask to every cubic foot of space. The higher the temperature during fumigation the less time is necessary to produce 100 per cent. kill.

Powders.

A very widely used powder during the last war was N.C.I. powder made of napthalene 96 per cent., creosote 2 per cent., iodoform 2 per cent. The chief objection to this powder is that it is rather irritant in some cases and tends to be somewhat moist. A more recent powder (Moore, 1918) the constituents of which are 20 grms. talc, 1 c.c. creosote and $^1/_2$ grm. sulphur, has been shown to be less irritant and far more effective.

Liquid Insecticides.

A 2 per cent. solution of lysol or carbolic acid may be used to soak infested underwear or to treat infested portions of the body. Another effective emulsion for body treatment can be prepared by mixing equal parts of kerosene and olive oil or soft soap. A hot water and soap bath should follow all treatments.

Head Louse (*Pediculus humanus capitis* De Geer).

The head louse is somewhat smaller than the body louse but very similar in appearance and life history. As the name suggests it favours the scalp and is rarely found off the head of its host. The eggs or nits are attached to the hairs and are rather difficult to dislodge. The blood sucking habits of the insects produce severe irritation and scab-covered sores.

Fig. 12.
The Head Louse—Male and female (enlarged).

Fig. 13.
Egg or Nit of Head Louse attached to a hair (highly magnified).
(After Patton.)

CONTROL.

Precautions similar to those recommended against the body louse should be taken. Infested heads should be treated with 2 per cent. carbolic or equal parts of kerosene and olive oil. Warm vinegar has also been recommended. The head should be swathed in a cloth or towel to keep the hair moist for about an hour, after which a warm soap shampoo is advisable. A second treatment in about seven or eight days will ensure the destruction of any lice which may have hatched from eggs surviving the first treatment.

The Crab Louse or the Pubic Louse (*Phthirius pubis Linn*).

The crab louse is very characteristic in appearance and as the name suggests looks something like a very tiny crab. The general life history of the louse resembles that of the head louse excepting that the insect characteristically infests the hairs of the pubic region and arm pits.

CONTROL.

Badly infested portions of the body should be shaved before treatment with one of the following lotions or ointments:—

Corrosive sublimate 1 part, alcohol 100 parts, water 400 parts.
Naphthalene 4 parts, soft soap 1 part.
Officinal mercurial ointment (this sometimes causes severe irritation).
Kerosene and olive oil equal parts.

Fig. 14.
The Pubic Louse.
(After Patton & Cragg.)

Fleas.

There are many different species of fleas and they are commonly known according to the host which they favour, as dog fleas, cat fleas, rat fleas, human fleas, mouse fleas, etc. It must not be inferred, however, that every flea found upon a dog is a dog flea, or upon a rat is a rat flea. A great deal of latitude as regards hosts exists and only a specialist can accurately determine the species. Excepting in special cases, however, the exact species of flea concerned will be of little importance. All fleas favour warm-blooded hosts and have a comparable life history.

Fig. 15.
The Dog Flea (enlarged).
(After Gibson & Twinn.)

Fleas are admirably adapted for their specialised mode of life, their shiny compressed forms slipping easily between the hairs on the host body, and their well developed jumping legs enabling them to easily obtain a host immediately their immature stages in the soil have been completed.

RELATION TO DISEASE.

The rat flea (*Xenopsylla cheopis* (Roth.)) is of world-wide importance because of its association with bubonic plague, but a number of other fleas including the dog flea (*Ctenocephalides canis* (Bouche)), the cat flea (*C. felis* (Curt)) and the human flea (*Pulex irritans* L.) have now been proved carriers of this disease.

LIFE HISTORY.

Adult fleas spend the majority of their time on a warm-blooded host and lay their eggs in this situation. The eggs soon fall to the ground and in a few days give rise to tiny worm-like larvae which shelter in any dust or litter. The food consists of organic material, mainly the excreta of adult fleas which is copiously dropped and becomes mixed with the dust or floor covering. After a week or more in this stage the larva pupates in a silken cocoon and finally emerges as an adult. As is the case with all the insects so far mentioned the length of the life cycle varies greatly under different conditions. In warm weather little more than two weeks will be necessary for development from egg to adult, while under cold conditions several weeks or even months may elapse before maturity is reached. Dog fleas have been known to live 58 days without feeding.

CONTROL.

In controlling fleas the first essential is to locate the host animals which will usually prove to be cats, dogs or rats. After treating or destroying the hosts, infested premises can then be effectively dealt with. A good universal spray which may be used for treating sheds, kennels and outhouses is kerosene emulsion.* This may also be used for washing infested animals.

Phenyle, hot water and soap, creosote or creosote emulsion may also be used to treat infested buildings.

The main essential is to see that corners, cracks and crevices are well flushed out with liquid. Indoors or for treating upholstered furniture, thorough spraying with any proprietary fly spray is recommended. Flaked naphathalene sprinkled under floor covers, etc., will also be found beneficial.

Certain powders for the treatment of animals are very effective, those containing pyrethrum or derris being most universally recommended. It is best, if animals are placed on sheets of paper while being treated so that stupified fleas falling from the fur may be later gathered up and burned.

The Hay Itch Mite (*Pediculoides ventricosus* (Newport)).

Persons associated with hay, chaff or grain may sometimes be affected by an irritation which is popularly known as hay itch or chaff itch. The cause of this itch is by no means obvious and the resulting dermatitis has been variously attributed to fleas, scabies, measles, hives, allergy, etc. The true cause of the rash is the presence of a tiny mite, *Pediculoides ventricosus*. This mite is parasitic mainly upon the larval stages of certain insects, especially those such as wheat weevils, grain weevils, grain moths, etc., intesting stored and dried products. A very common host is the caterpillar stage of the angoumois grain moth (*Sitotroga cerealella* Ol.). The grain moth breeds in wheat grains and so the association between chaff, hay or straw and hay itch is clear.

Vide Appendix.

LIFE HISTORY.

The mites do not lay eggs, but living young are born and these are sexually mature at birth.

The female at first measures only about 1/100 inch (Swan, 1934) in length but after being fertilised and attached to a host for a time she swells enormously. A single female may produce from two to three hundred young during its life of a week or more so that a severe infestation can quickly arise if host insects are plentiful.

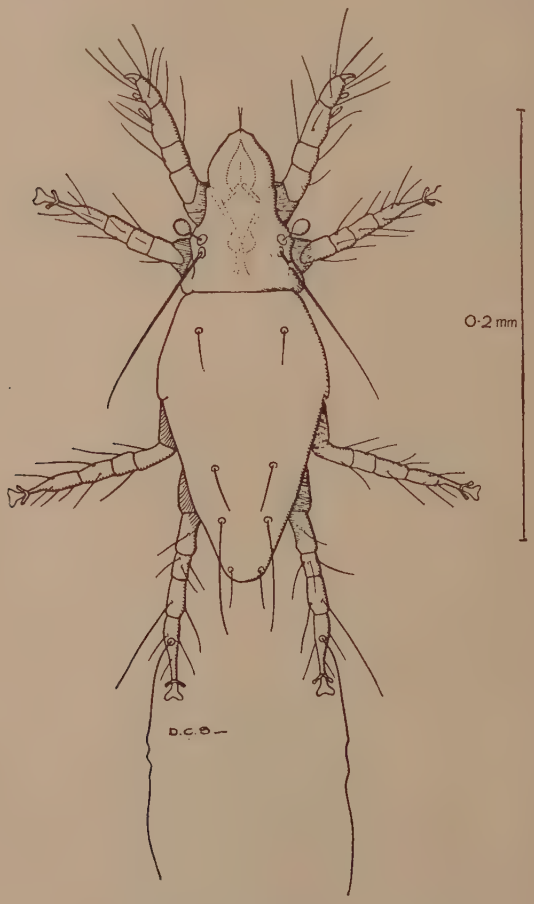


Fig. 16.

Hay Itch Mite. Non-gravid female.
(After Swan.)

Relation to Man. –If insects were the only creatures attacked this mite could be regarded as entirely beneficial, but unfortunately, persons who come in contact with infested material are liable to attack. Man is not a normal host for the mite and it does not persist long on the human body, nor burrow under the skin (Askin, 1924).

The mite is most active during warm weather. The intensity of the irritation caused varies with the individual attacked.

The symptoms usually become evident a few hours after attack, when itching may commence and wheals appear with a small central vesicle from which a watery fluid may be squeezed.

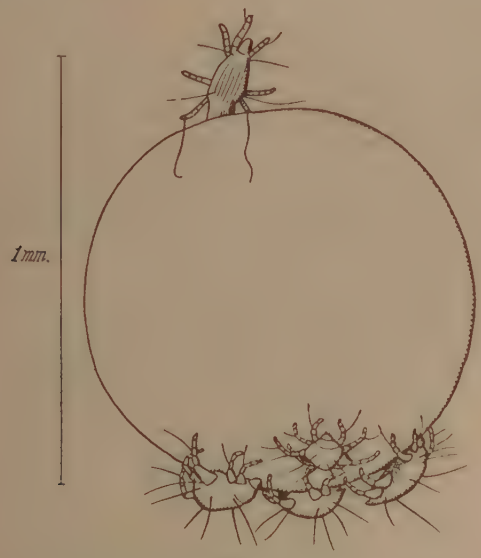


Fig. 17.
Hay Itch Mite. Gravid female showing four males grouped around the genital aperture.
(After Swan.)

The irritation may be intense for the first few days, especially when the patient is warm in bed. After about the third day the irritation gradually subsides.

The importance of this mite in military camps is that soldiers are frequently bedded down on straw, and failure to use straw that is free from grain may cause serious and widespread inconvenience to the troops.

CONTROL.

The first precaution should be taken by the farmer. Hay should be cut before the grain has matured so that on drying it will be pinched and shrivelled and unsuitable for the breeding of grain moths and weevils.

When bedding is being selected, straw stubble from which the grain has been stripped should be used for preference, otherwise early cut hay. Hay from stacks over a year old should always be viewed with suspicion. Oaten hay is usually less liable to infestation than late cut wheaten hay.

When it is necessary to handle infested material, sulphur should be dusted through the underclothing and any exposed parts of the body may be smeared with vaseline or oil.

In order to eradicate an infestation, all material possible should be burnt. Where this is not desirable, fumigation* may be resorted to.

Vide Appendix.

Floors, etc., may be sprayed with any strong insecticide, such as kerosene emulsion or lime sulphur 1-60. Clothing is not likely to remain infested for long, but heat treatment as recommended for lice would be effective and under Australian conditions exposure to the summer sun for several hours would be adequate.

For alleviating the irritation, various lotions such as calomine, dilute carbolic or warm water and vinegar have been recommended. Hot baths containing bicarbonate of soda have also been found soothing.

Bed Bugs (*Cimex lectularius* L.).

Bed bugs are oval, flattened, reddish-brown wingless insects, measuring about ¼ inch in length when full grown.

They possess sucking mouthparts and feed upon mammalian blood, particularly that of man.

On account of their nocturnal habits and the fact that during the day time they hide away in cracks and crevices, the insects are apt to be overlooked until the infestation has reached considerable proportions.

Fig. 18.
The Bed Bug (enlarged).
(After Gibson and Twinn.)

LIFE HISTORY.

The females deposits comparatively large yellowish white eggs in cracks and crevices used as hiding places. A single insect may lay from 200 to 500 eggs over a period of several months. The young, which have the general form of the adults, hatch in about 10 days and maturity is reached after a further five or six weeks. The duration of the different stages in the life cycle may be greatly lengthened under adverse temperature and food conditions. Normally fed, the adults will live about a year and starved individuals have been known to survive for 136 days (Herms, 1939).

Relation to Disease.—The bed bug appears to be relatively unimportant as a disease carrier, but should nevertheless be regarded as a potential menace to public health.

CONTROL.

Fumigation with hydrocyanic acid gas* is the most effective treatment against a severe infestation of bed bugs, but sprays may be satisfactory against light outbreaks. The cracks and crevices in walls and furniture, especially beds, should be

Vide Appendix.

thoroughly sprayed with kerosene-pyrethrum* or proprietary fly sprays or a mixture of half pint of cresol or carbolic to a gallon of kerosene. The insects must be thoroughly drenched by the spray and a repetition of the treatment should be made in about seven or 10 days and again if necessary.

Cockroaches.

Several species of cockroaches are now general household pests. In this country some of the native varieties have become semi-domesticated and, in addition, several introduced forms are to be met with.

The large reddish-brown winged cockroach (*Periplaneta americana* L.) is probably the most universal. It measures about 1½ inches in length and is the largest domestic roach found in this State.

Cockroaches are practically omnivorous but are particularly fond of foodstuffs favoured by man. On this account the insect frequently assumes plague proportions in kitchens and galleys.

Fig. 19.
The American Cockroach.
(From U.S. Dept. Agric.)

LIFE HISTORY.

The eggs of the cockroach are developed in a chitinous capsule or packet which is carried for a time protruding from the abdomen of the female. These capsules may be found attached to rafters, books, boxes, or other rough surfaces. In the case of the American cockroach, attempts may be made to cover the egg capsules with bits of chewed paper, etc.

The young on hatching, have the general form of the adult. They moult several times and reach maturity after several months.

Vide appendix.

The exact duration of the different stages varies considerably. For the egg stage 70 days at 77° F. has been quoted as the developmental period (Haber 1919), but under Australian summer conditions this time is probably reduced. Several months or perhaps a year may elapse before the adult stage is reached. The female may lay a number of capsules, each containing approximately 16 eggs. The longevity of the adults is considerable for an individual at present under observation in this laboratory has already survived for over two years.

Relationship to Disease.—On account of its association with offal and scraps of all kinds the cockroach is a potential mechanical carrier of disease. Roaches have been known to eat infected excrement and disgorge infective material some time later.

CONTROL.

Meticulous care with regard to the disposal of foodstuffs and scraps is the first essential in any attempt to control this pest.

Sprays.

The use of kerosene-pyrethrum* fly sprays, where direct contact can be obtained, is effective, but on account of the insects' nocturnal habits this contact is usually difficult to achieve.

Dusts.

The use of various dusts to be sprinkled into cracks and crevices or in situations where the roaches are known to visit, is widely recommended.

Sodium fluoride is the most effective of these dusts and under dry conditions can be thoroughly recommended. Borax is a dust which, although less effective than sodium fluoride, is not poisonous to humans. For ordinary household infestations, borax or borax and sodium fluoride mixed may be used. The higher the proportion of the latter the more rapid will be the results obtained.

In order to be effective, dusts must be finely ground and dry. They depend for their efficiency not upon the fact that they are palatable and so eaten by the roaches, but upon the fact that the tiny particles cling to the legs and antennæ of the insects and are subsequently swallowed when these members are licked and cleaned in subsequent grooming operations.

Baits.

A bait said to be very effective is prepared from phosphorus rat paste smeared over the inside of a piece of cardboard which has been previously rolled up so as to form a cylinder.

A widely publicised bait employing plaster of Paris, flour and water has been shown to be founded upon inaccurate observations. Fermenting materials, such as stale beer, are said to be very attractive to the cockroaches, and jars partly filled with such liquid, with sticks leant against the outside to facilitate the ascent of the insects, are said to kill many, which fall in and drown.

The Red-backed Spider (*Latrodectus hasseltii*).

The red-backed spider is closely related to the black widow (*L. mactans*) of America, and shares with it an evil reputation on account of its venomous bite. It is the only spider whose bite is known to cause serious illness to humans in Western Australia. One of the so-called trap-door spiders, or funnel web spiders, has been known to cause serious trouble in the Eastern States.

**Vide* appendix.

The adult female spider, which is about $\frac{3}{4}$ inch in length, can be easily recognised by its general dark colouration, relieved by a prominent red streak on the abdomen. The male spider is very much smaller than the female.

This spider may cause considerable inconvenience from its habit of invading outhouses, sheds, latrines, and similar man-made structures. The creature is nocturnal in its habits and usually spins its web in some dark corner or under a bench or seat, with possible dire results to future occupants.

The eggs are surrounded by a light coloured silken cocoon about $\frac{1}{2}$ inch in diameter.

Fig. 20.
The American Black Widow Spider, showing pattern on under side of body.
(From Univ. Miss. Agric. Exp. St.).

CONTROL.

Where accessible, the adult spiders may be swept down with a stiff broom or stick and destroyed. The egg masses, which are not carried about by the female, may also be sought and disposed of. Care should be taken, if gathering these by hand, as the female spiders are often near and will sometimes actively defend their eggs.

Kerosene-pyrethrum fly sprays are not very satisfactory against this pest as their effect is usually only transitory. Black leaf 40 or nicotine sulphate, two teaspoonsful plus one ounce of soap to the gallon of water is recommended, but the most effective treatment yet found is creosote.

Creosote is not only lethal but also a repellent. It should be sprayed under strong pressure into all cracks and crevices where the spiders might be lurking and the undersides of latrine seats might be painted with creosote or crude oil to retard re-infestation.

Where it is not possible to use pure creosote for all operations, creosote emulsion at about one part to eight parts of water could be used after the most heavily infested sites have been thoroughly treated with the raw product.

APPENDIX.

I. Kerosene emulsion—Stock solution:—

½ lb. soap.
1 gallon water.
2 gallons kerosene.

Dissolve the soap in the boiling water. Remove from fire and add the kerosene, at the same time agitating the solution for five or ten minutes with a spray pump so as to get a thorough mix. Dilute for general use to about 1 part of stock to 8-10 parts of water.

Warm water and constant agitation during the dilution process will ensure a stable mixture.

Creosote and *Crude oil emulsions* are made by substituting these ingredients for the kerosene in the above formula.

II. Kerosene-pyrethrum fly spray.

The preparation is made up as follows:—

Pyrethrum, ¾ lb.
Kerosene, 1 gallon.
Methyl salicylate, 3 ounces.

Steep the pyrethrum and kerosene for 24 hours and then strain off the liquid. The methyl salicylate may be added to impart a more pleasing odour to the mixture.

III. Fumigation.

(a) Hydrocyanic acid gas.

The standard formula for preparing the gas is as follows:—

Sodium cyanide, 1 ounce.
Commercial sulphuric acid, 1½ fluid ounces (3 tablespoonsful).
Water, 2 fluid ounces.

Preparations such as zyklon B, liquid hydrocyanic acid and cyanogas dust A may be used as sources of this fumigant.

In the case of a two-storey building each storey is treated as a separate unit and made as airtight as possible, but as the gas tends to rise the dosage on the bottom floor should be somewhat increased and the upper ones somewhat decreased. The dosage may be worked out on the basis of 1 lb. of cyanide to 1,000 cubic feet of space for the ground floor.

In preparing the mixture the sulphuric acid should be poured into the water and not vice versa, and the cyanide should be suspended over the earthenware crock, containing the liquid, in a paper bag and lowered in as the door is being closed.

Buildings treated with hydrocyanic acid gas should be sealed for at least 12 hours and from 24-36 hours if possible.

On account of the high toxicity of the gas, fumination whenever possible should be undertaken by a professional or experienced fumigator.

(b) Carbon-bisulphide.

The fumigant should be used at the rate of 4 lbs. per thousand cubic feet of space and the container sealed for 48 hours. Where leakage is suspected the dosage should be doubled.

If a fumigation chamber is not available the dosage may be increased and a sound tarpaulin draped over the goods and the edges sealed with earth. As the gas generated is heavier than air the fumigant should be applied on the top of the pile of goods.

Warning.—The fumigant is inflammable and explosive.

REFERENCES.

Anon., 1940: "Science in War"—Penguin Special.
Askins, R. A., 1924: *Brit. Med. Jour.*, No. 3334, 950.
Buxton, P. A., 1940: "The Control of Lice," *Brit. Med. Jour.*, 1940, 2, No. 4165, p. 603.
Davidson, Capt. J., 1918: "Some practical methods adopted for the control of flies in the Egyptian Campaign." *Bull. Ent. Res.*, Vol. 8, p. 297.
Haber, V. R., 1919: "Cockroach pests in Minnesota with special reference to the German cockroach." *Agric. Exp. Stat. Univ. Minn. Bull.* 186.
Herms, W. B. H., 1939: "Medical Entomology." The Macmillan Co., N.Y.
Hogan, T. W., 1940: *Health Bulletin*, Nos. 61 and 62, Dept. Pub. Health, Victoria, p. 1617.
Moore, W., 1918: "Methods of control of the clothes louse." *Jour. Lab. and Clinical Medicine*, Vol. III., No. 5.
Pescott, R. T. M., 1939: *Health Bulletin*, Nos. 59 and 60, Dept. Pub. Health, Victoria, p. 1649.
Swan, D. C., 1934: "Hay Itch Mite in South Australia." *Jour. Agric. S. Aus.*, Vol. 37, p. 1289.

Studies in Sheep Husbandry in W.A.

ii.—The Influence of Feeding during late pregnancy on the Birth-Weight, Growth Rate, and Quality of the Lamb.

E. J. Underwood and F. L. Shier.

The principal objects of the farmer aiming at success in the production of fat lambs are to obtain as many lambs as possible from his ewes, i.e., the maximum percentage "drop," and to see that these lambs grow as fast as possible so as to have them at marketable size and quality in the shortest time. The primary importance of selecting the most suitable breed of ewe and of ram for this purpose is well recognised, but the fact that feed can be equally important is not so well appreciated. In a previous article Underwood and Shier (1941) described an experiment with Border Leicester x Merino ewes in Western Australia, which demonstrated clearly the importance of the feeding treatment prior to and during the mating period on the lambing percentage. A highly significant increase in the percentage of lambs born was produced by first bringing the ewes down in condition, and then, shortly before and during mating, raising their plane of nutrition. This is the process known as nutritional "flushing."

It seemed logical to follow up this work by an investigation of the significance of the plane of nutrition during pregnancy itself. During the first half or two-thirds of pregnancy the ewe has little extra food requirements above that of the non-pregnant animal. The aim of the farmer should be to keep the ewe in a healthy, thrifty condition during this time. During the last part of pregnancy, however, not only do the nutritive demands of the developing foetus become much greater, but the growth of the milk-secreting tissue of the udder may also be influenced by the feeding treatment at this time. Extra feeding during the last third of

pregnancy might, under certain conditions therefore, be expected to stimulate the milk secretion of the ewe; and further, since the growth rate of the lamb during the first three months has been shown to be largely influenced by the milk yield of the mother, to improve the growth and development of the lamb.

Evidence that such an effect is possible is provided by Hammond (1932) who divided a flock of Suffolk ewes into three groups—good, medium, and poor—according to the condition at lambing. Taking average weights of the lambs from each group, it was found that the ewes in medium and good condition not only produced heavier lambs at birth, but the superiority was still shown at 20 weeks of age. It should be noted, however, that the numbers of lambs involved were exceedingly small, especially in the case of the singles and triplets, and no individual weights are submitted to give an idea of the variation within groups. Verges (1939) selected 30 Border-Leicester x Cheviot ewes, mated to Suffolk rams, and maintained them under the same conditions up to the end of the third month of pregnancy. They were then separated into two equal groups; one was fed on lucerne hay and straw, so that the average gain in weight during the last two months of pregnancy was only 1 lb.; the other group was fed on lucerne hay and a high-protein concentrate mixture, so that the average gain in weight during this time was 39.5 lb. Even under these extreme conditions the extra feeding resulted in no increase in mean birth-weight of the single lambs, but the twin lambs were 47 per cent. heavier at birth, the weights being 9.0 lb. (mean of 16 lambs) compared with 6.1 lb. (mean of 14 lambs) from the poorly fed group. The heavier lambs at birth were found to have made the best gains in post-natal life. Part of these better gains was due to the considerably higher milk yield of the ewes which were well fed prior to lambing. All the ewes from the poorly fed group were dry two months after lambing. The lower growth rate of the lambs from the poorly fed ewes was accompanied by a much lower quality of carcase. At the same age the carcases of these lambs contained a higher proportion of bone, a smaller proportion of muscle, and a much smaller proportion of fat. Thomson and Fraser (1939) found the weight and vigour of lambs at birth and the milk yields of the ewes to be greatly influenced by the feeding of the ewe during pregnancy. A flock of 42 Scottish Greyface ewes mated to Suffolk rams were divided into three equal groups. The first group was fed sufficient to gain only 8 lb. per head, while in lamb; the second group was fed the same up to one month before lambing, when they were heavily fed with concentrates and gained an average of 20 lb. per head; the third group was heavily fed throughout and gained as much as 50 lb. per head. No appreciable differences between the second and third groups were found either in the birth-weights of the single or twin lambs, or their vitality, or in the milk yield of the mothers. In the poorly fed group both the singles and twins *averaged* more than 2 lb. lighter at birth than those of the other groups, but it should be stressed that the numbers of *singles* involved were exceedingly small (4, 5 and 6 respectively in the three groups) and no individual weights are submitted. Many of the lambs of the poorly fed group, particularly the twins, were stated to be weak and lacking in vitality, and were unable to suckle their mothers. No weighings of any of the lambs subsequent to birth were carried out but some of the ewes in this group were observed to have very little milk.

It is clear from these experiments that the plane of nutrition of the ewe during late pregnancy can be a highly important factor in controlling the birth-weight, growth rate, and quality of the lamb, at least in the case of twins and triplets. It is important, therefore, to examine the position in this respect under the conditions existing in the lamb-raising areas of Western Australia. Under average seasonal conditions in these areas the greater part of the period of

pregnancy coincides with the period when the poorest dry grazing is available to the ewe. When the autumn rains appear early, ample green grazing, either as pasture or sown crops, will be available to raise the plane of nutrition of the ewes during the latter part of pregnancy. If the rains are late or even "normal" in their incidence, however, this vital period is one of poor nutrition for the ewe unless adequate provision in the way of supplementary feeding is made.

Experiments to determine the effect on the lamb of supplementary feeding of the ewe in a district typical of the lamb-raising areas of Western Australia were, therefore, devised. The results of the first of these experiments, carried out at the Avondale Research Station during the period December, 1940, to November, 1941, are presented in this paper. The general climatic and grazing conditions at this Station have been described previously (Underwood and Shier, 1941).

Experimental Procedure.

To ensure that the feeding treatment should begin at a definite time in the pregnancy period it was necessary to have a flock of ewes which were due to lamb over a short and known period. Such a flock was obtained by mating 450 Border-Leicester x Merino ewes, aged $2\frac{1}{2}$-$5\frac{1}{2}$ years which had all previously produced lambs, with 16 Southdown rams raddled on the brisket. From these the marked (i.e., mated) ewes were taken off twice weekly and their ear-tag numbers and the date recorded. From these marked ewes two even groups of 150, with an equal age distribution and all due to lamb over a period of three weeks, were selected. The two groups were termed Group I. "Fed Group," and Group II. "Controls." Until the commencement of supplementary feeding the two groups were run as one flock.

The feeding of Group I. was started 5-6 weeks before lambing, but in two sections with an interval of one week so as to allow for the spread of the lambing period. Any ewes which did not lamb during the expected period were eliminated from the experiment. At lambing the ewes were inspected twice daily and all lambs were weighed to the nearest ounce, ear-tagged and recorded. From then on the ewes and lambs from both groups were run as one flock. The lambs were tailed and ear-marked when three to four weeks old and the males castrated by the Burdizzo method. After the first month the lambs were weighed at fortnightly intervals until forwarded by rail to the treatment works for slaughter. The lambs were dispatched when they reached a definite live-weight of 65-70 lb. in the first three consignments, and over 60 lb. in the last two consignments. In all five consignments were made. The pre-slaughter weights represent the weight at the farm approximately 24 hours before slaughter. At the works "hot" carcase weight to the nearest $\frac{1}{2}$ lb. (weight immediately after dressing) was obtained, and certain carcase measurements made for as many lambs as time and assistance would allow.

Feeding and Grazing Details.

During the mating period the ewes were pastured on freshly stripped oat, barley, and wheat stubble, containing a fair percentage of unthrashed heads. For the first 8-10 weeks of pregnancy the grazing was good dry subterranean and other annual "clovers" and annual grasses, such as barley grass and silver grass. After this time the grazing, which had become appreciably eaten out, was supplemented with 1 lb. oaten silage per head per day for a further period of seven weeks, and from then on until lambing with $1\frac{1}{2}$ lb. For the period 4-6 weeks prior to lambing the two groups were pastured separately, and, in addition to the silage supplement, the ewes of Group I. ("Fed Group") received $\frac{1}{2}$ lb. wheaten grain per head per

day. Some early rains were recorded approximately one month prior to the lambing period, but, whilst these were excellent for providing good growth on the fodder crops sown on fallow, they were insufficient to cause appreciable germination or growth on the unfallowed heavy land paddocks where the experimental ewes were being grazed. For the first month after lambing the grazing consisted of a crop of young green barley, and from then on alternately natural green pasture (subterranean clover base) and green barley crop.

RESULTS.

Although 150 ewes were initially allocated to each group, a number—42 in each case -were discarded from the final consideration for the reason that they failed to lamb at or near the expected time, or failed to lamb at all. This was necessary so that an accurate comparison of the two treatments could be made. In effect, therefore, each group consisted of 108 pregnant ewes. In Group I., 107 of these lambed to time, and one died in the course of lambing, while in Group II., 103 ewes lambed normally and five died from 3-5 weeks prior to the expected lambing date. From the general symptoms and the condition of the liver and the blood picture, the five ewes lost in Group II. all died from pregnancy toxaemia. Four of these ewes were carrying twins. The ewe which died in Group I. showed no such symptoms. The significance of these losses and their effect on the lambing results will be discussed later.

The lambing details are shown in Table I.

Table I.

	No. of Lambs Ear-tagged.		No. Lost at or shortly before Birth.		No. Died shortly after Ear-tagging.		Total Deaths (Lambs).
	Pairs Twins.	Singles.	Pairs Twins.	Singles.	Pairs Twins.	Singles.	
Group I. (Fed) ...	11	93	...	4	...	1	5
Group II. (Controls)	7½	91	*4½	*5	2	4	*22

* Including lambs lost with ewes dying from pregnancy toxaemia.

Statistical treatment of these results reveals that the difference in lamb losses in the two groups is highly significant ($P < .01$) by Fisher's X^2 test.

Twelve of the single lambs in each group were not marketed. Of these eight in Group I. and six in Group II. failed to reach the required weight before the last consignment was made, whilst the deaths after ear-tagging were one and four respectively. Three lambs in Group I. and two in Group II. were not marketed owing to a mishap at mustering on the day of the last consignment. In the case of the twins in Group I., seven (including six reared as twins) were marketed, whilst one died and 14 failed to reach market weight. In Group II., four were marketed (including one reared as a twin), four died and seven failed to reach the required weight out of the original 15. It is apparent that the ration fed had no significant effect in reducing the number of lambs which failed to reach marketable weight although the effect on the number of deaths after ear-tagging (two in Group I. and eight in Group II.) is striking. These losses have been illustrated in Table I.

The average birth-weight, age at slaughter, and carcase weight, for all single lambs are given in Table II., together with the birth-weight of all twin lambs, and the slaughter particulars which are available from such lambs when reared as twins. Owing to the comparatively small numbers of twins, and the still smaller number reaching marketable weight when reared as twins (a number of single losses in twins occurred), the details available for the twins are few. The number of lambs in each group are shown in brackets in Tables II., III., and IV.

Table II.

Group.		Birth Weight.	Age at Slaughter.	Pre-slaughter Weight.	Carcase Weight.
		lbs.	days.	lbs.	lbs.
I. (Fed) Singles	Ewes ...	8·4 (53)	134 (47)	66·3	32·0
	Wethers ...	9·0 (40)	118 (34)	67·4	32·3
	Means ...	8·6 (93)	127 (81)	66·8	32·1
II. (Control) Singles	Ewes ...	8·3 (42)	132 (35)	66·0	31·5
	Wethers ...	8·6 (49)	124 (44)	67·1	31·6
	Means ...	8·4 (91)	127 (79)	66·7	31·5
I. (Fed) Twins	Ewes ...	6·5 (13)	157 (4)	62·8	27·3
	Wethers ...	6·8 (9)	148 (2)	63·3	27·8
	Means ...	6·6 (22)	154 (6)	62·9	27·5
II. (Control) Twins	Ewes ...	5·3 (3)	...	...	...
	Wethers ...	6·3 (12)	155 (1)	68·0	30·0
	Means ...	6·1 (15)	155 (1)	68·0	30·0

Statistical examination of these results showed that there was no effect of the feeding treatment on the birth-weight of either singles or twins, or on the time (number of days) taken by the singles to reach a given live or pre-slaughter weight. There was, however, an effect of sex, male lambs had a higher birth-weight (approximately 7 per cent.), and also took a shorter time to reach the same live weight than ewe lambs. These differences in favour of the male lambs are highly significant ($P < .01$).

The individual birth-weights were also grouped and examined on the basis of early and late lambs. Male lambs born in the first week and in the last week of the lambing period both averaged 8.8 lbs., whilst the figures for the ewe lambs were 8.7 and 8.4 respectively. Obviously there was no difference in the birth-weight of early and late lambs. This supports the statement made previously that the early rains were insufficient to produce any material growth on the paddocks where the experimental sheep were being grazed.

Table III. gives the number of days taken by both ewes and wethers to reach "maturity" for different birth-weights. It indicates the importance of high birth-weight by showing the quicker rate of growth of the heavier lambs at birth, and illustrates further that, at the same birth-weights, the wethers have grown faster than the ewes.

TABLE III.

Birth Weight (lbs.).	Wethers.		Ewes.	
	Age.	Live Weight.	Age.	Live weight
	days.	lbs.	days.	lbs.
5–7	138 (3)	63·8	148 (3)	65·0
7–8	130 (16)	66·6	140 (18)	66·3
8–9	123 (25)	67·7	134 (41)	66·3
9–10	117 (21)	67·0	127 (13)	66·4
10–11	115 (9)	68·4	117 (4)	67·3
11–12	106 (4)	69·2	105 (2)	65·5

Hammond (1932) and Verges (1939) have shown that the composition of the carcase (muscle, fat, and bone) and its conformation (both important factors in its evaluation for meat purposes) are affected by the rate of growth of the animal. Pálsson (1939) has described a method of estimating carcase quality by means of a number of internal and external measurements. The following measurements taken as described by him were obtained from a number of carcases (single lambs only) and these are summarised in Table IV.:—

F = length of leg:

G = width of gigots*:

H = depth of gigots:

K = length of body from the base of the tail to the base of the neck:

M = length of fore-cannon.

T = length of tibia and tarsus:

Th = depth of thorax or the maximum "depth" of the chest behind the shoulders.

In addition the weight, length (M), and minimum circumference of the left fore cannon bone (efficient indices of the proportion of bone in the carcase) were obtained. The position of these measurements is indicated in Figure 1.

TABLE IV.

MEAN EXTERNAL MEASUREMENTS OF CARCASES.

	F.	G.	H.	K.	T.	Th.	Left Fore Cannon Bone.			Carcase Weight.
							Weight.	Length.	Min. Circumference.	
	cms.	cms.	cms.	cms.	cms.	cms.	gm.	cms.	cms.	
Group I.	24·4 (36)	21·3	11·5	59·5	17·7	24·3	30·0 (23)	10·9	4·1	31·8†
Group II.	24·9 (35)	21·2	11·4	59·8	17·8	24·6	30·5 (24)	11·1	4·2	31·1†
Mean of all Wethers	24·8 (46)	21·2	11·6	59·5	17·8	24·8	31·1 (25)	11·0	4·2	31·7†
Mean of all Ewes	24·7 (25)	21·3	11·3	59·8	17·7	24·2	29·3 (22)	10·9	4·1	31·9†
Mean of all Lambs	24·8 (71)	21·2	11·5	59·7	17·8	24·6	30·3 (47)	11·0	4·1	31·4†
Southdown x BL—Cheviot (after Pálsson)	23·8	22·4	12·6	60·0	18·6	25·0	35·4	10·8	4·5	38·0
Iceland (after Pálsson)	27·2	21·0	11·6	61·0	19·9	26·7	36·5	11·9	4·4	30·5

† Carcase weight refers, in this table, to "hot" carcase weight, less 4 per cent.

*The term "gigot" is not used in this country but the measurements G and H indicate the development of the hind-quarters and the fullness of the leg joints.

The close similarity of these figures shows clearly that no difference between the two groups or between sexes existed either in carcase conformation or in carcase composition as indicated by the cannon bone measurements.

No direct comparison of these measurements with those from elsewhere is possible since no such measurements on lambs of similar weight and breeding are available. Measurements for lambs of the same age and weight of the slower maturing Iceland breed, and of heavier lambs of about the same age of the Southdown x Border Leicester-Cheviot cross obtained by Pálsson (1939) are, however, included in Table IV. Calculation of the proportion of skeleton in the carcases by weight using the values of T (length of tibia and tarsus), and the weight of the cannon bone, and the regression equations of Pálsson, shows that the mean proportion of skeleton in our carcases is 13.0 per cent. compared with 15.4 in the Iceland breed, and 10.4 per cent. in the Southdown x Border Leicester-Cheviot. It is reasonable to argue from this that our lambs were on the average of better quality, i.e. with less bone and more muscle and fat than the Iceland lambs. It cannot be argued, however, that the Southdown x Border Leicester-Cheviot lambs are of better "quality" than ours since they are appreciably heavier in weight. It is possible that our lambs, if they had been allowed to attain the same mean carcase weight, would have shown a decreased proportion of skeleton weight similar to that of the Southdown x Border Leicester-Cheviot lambs.

As it was not possible to dissect the carcases, no internal measurements could be made which would enable calculations of the proportions of fat and of muscle in the carcases to be carried out.

Biochemical Data.

The calcium content and the level of "ketone bodies" in the blood of two groups of 20 ewes, selected at random from Groups I. and II., were carried out at fortnightly intervals during the last three months of pregnancy. These determinations, together with a number of other estimations, were also carried out on those ewes which were diagnosed as having died of pregnancy toxaemia. A detailed consideration of these analyses will be published elsewhere, but it is felt that the results are of sufficient practical importance to warrant brief consideration in the present paper. The disease (pregnancy toxaemia) is associated with under-nutrition and loss of condition during late pregnancy, and a very fatty liver and a high concentration of certain toxic substances known as "ketone bodies" have been found constantly to occur in the blood of affected animals.

No low levels of calcium were found at any time in the blood of ewes in either group, or in any of the ewes which died of pregnancy toxaemia. The blood ketone levels showed a tendency to rise during late pregnancy, particularly in the Controls, although very few ewes showed really high values. A short period of starvation (48 hours) resulted in a marked and rapid rise in the blood ketone level of four Control ewes. A much smaller rise was induced by the same means in a similar group of ewes from the Fed Group. It should be pointed out, however, that although the ketone levels produced in this way in the Control ewes were just as high as those found in the affected ewes no symptoms of pregnancy toxaemia developed.

It is evident that an adequate level of supplementary feeding and the avoidance of any sudden checks in the treatment of the ewes during late pregnancy are, under the conditions of the present experiment which characterise those of much of the agricultural areas of Western Australia, highly important factors in helping to reduce losses, or the chance of losses, from pregnancy toxaemia. These findings confirm the recommendations of Toop (1941) who has recently given an account of the disease, its nature, treatment, and relation to Western Australian conditions.

DISCUSSION.

Some comment on the feeding treatment and condition of the ewes prior to lambing is a necessary preliminary to any discussion of the actual results. Both groups received a supplement of 1-1½ lb. of oaten silage per head per day for the last 10-12 weeks of pregnancy. This did little more than make good the gradually diminishing dry grazing of the paddock, as it supplied less than ½ lb. dry matter per day, and this dry matter contained 34.2 per cent. crude fibre and only 6.8 per cent. protein. As far as could be judged from appearance the ewes of Group II. barely maintained their live weights under these conditions and had drawn upon their own body tissues for the development of their lambs. No weighings were carried out as it was felt that the frequent mustering and weighing of such large groups near to lambing, might result in undue losses of both ewes and lambs.

The decision that the extra supplement during the last 5-6 weeks of pregnancy to the ewes of Group I. should be ½ lb. wheat per sheep per day was made because it represented a "practical" ration and the cheapest and most readily available concentrate. Such a ration would supply appreciable quantities of available energy

and of protein, both of which have been shown to be deficient in the dry grazing normally available to sheep in these areas in the late summer (Underwood, Beck, and Shier, 1939). Although the grain used contained only about 10 per cent. protein, and cannot therefore be regarded as a protein concentrate, it should be pointed out that this is probably more than double that of the dry grazing available at the time (Underwood, Shier, and Harvey, 1937). At this level of feeding the total amount of wheat given to each ewe in Group I. was only 15-20 lb., but the better condition and general appearance of these animals at lambing was very noticeable. On the other hand the Control ewes (Group II.) at the time of lambing were in a reasonably thrifty condition and similar to the general condition of the majority of breeding ewes throughout these areas at this time of the year.

Consideration of the results as a whole make it clear that the outstanding effect of raising the plane of nutrition of the ewe during the last month to six weeks of pregnancy, by means of the small supplement of wheat, has been a highly significant reduction in losses of ewes and lambs, both before and after lambing. This is strikingly illustrated in Table I., showing five lambs lost in Group I., the Fed Group, against 22 lambs lost from the Controls. These 22 included nine lambs from five ewes which died of pregnancy toxaemia. No losses from this disease occurred in the Fed Group. The practical importance of this is obvious, especially as the cost of the wheat supplement was only about 1s. per head, or £5 per hundred ewes. The value of the losses of ewes and lambs which have been prevented by the feeding treatment is, under the conditions of the present experiment, about three times that of the cost of the supplement.

The extra feeding to the ewes of Group I., however, has had no significant effect in raising the birth weight of either single or twin lambs, or in increasing their rate of growth. It is evident that the mothers have been able to supply the nutrients required for the development of the lamb *in utero* from their own body tissues. This is in agreement with the findings of Hammond (1932) and Verges (1939) for the singles, though not with that of Thomson and Fraser (1939). The absence of any effect on the birth weight or growth rate of the twin lambs is surprising in view of the findings on this point of the three groups of workers just mentioned. The amount of supplementary feeding given to the ewes of the Fed Group in the present experiment was, however, quite small and it is quite possible that a much heavier level of feeding, particularly with a more protein-rich material, might have been effective in raising the birth weight and rate of growth of both singles and twins.

In this connection it should be pointed out that the average birth weights and the time taken to reach a live weight of 65-70 lb. did not by any means approach the possible genetic maximum for lambs of this breeding. The mean birth weight of all single lambs (8.5 lbs.) and the number of days taken to reach a live weight of 65-70 lbs. (127 days) are very similar to the figures quoted by Bonsma (1939) for lambs of the same cross, namely, 8.7 lbs. and 128.6 days. They are, however, appreciably lower than values obtained in Western Australia for the same cross in previous years. Thus, in 1935 the average birth weight of the single lambs was 9.1 lbs. (Shier and Davenport, 1936) and in 1932 and 1933 the figures were 10.7 and 10.2 lbs. respectively (Sutton *et al.*, 1934). In 1932 the time taken by the lambs to reach the required live weight of 65-70 lbs. was 99 days and in 1933 only 92 days, which is four to five weeks shorter than in the present (1941) experiment.

The importance of a heavier weight at birth in reducing the time taken by lambs to reach a similar live weight is strikingly illustrated in Table III. On the average each increase of 1 lb. in the birth weight reduced the time taken to reach

65-70 lbs. live weight by approximately one week. A quicker rate of growth in the heavier lambs at birth was also found by Sutton *et al.* (1934) and Bonsma (1939). The practical significance of this "quicker" growth is obvious, particularly in the Western Australian lamb belt, where the season of good pasture is undoubtedly short. Any treatment available to the farmer which might raise the birth weight of lambs, such as heavy feeding of the mother during late pregnancy, therefore, becomes of great practical significance, although the importance of other factors affecting birth weight, such as size of ewe (bigger ewes produce bigger lambs) should not be overlooked.

Another point of great interest arises from a comparison of the growth rate of the lambs in the present experiment and those in the 1932 and 1933 experiments mentioned previously. It will be noticed that the time taken to reach the same pre-slaughter weight is appreciably shorter in the 1932 and 1933 lambs than the 1941 lambs of the same birth weight. In other words the quicker growth rate of the 1932 and 1933 lambs is greater than can be accounted for by their heavier birth weight. As the feeding conditions after lambing were very similar (young cereal crops and clover pasture) in the three years and, as the growth rate of lambs in the first few weeks is known to be largely influenced by the milk yield of the mothers, this strongly suggests that the pre-lambing feeding in 1932 and 1933 resulted in a higher milk yield of the ewes, compared with the 1941 ewes as well as in higher birth weights of the lambs. These factors together would be reflected in a very high growth rate of the lambs. It suggests, further, that a good lamb "season" may be as much determined by the conditions prior to birth—either early rains or particularly good grazing or hand-feeding—as by the conditions subsequent to birth, which are ordinarily regarded as determining the "quality" of the season.

Although the small but significant difference in birth weight (7 per cent.) in favour of male lambs as compared with females has no practical importance, it agrees with that recorded by Shier and Davenport (1936) and by Bonsma (1939). An analysis of co-variance, which enabled the sexes to be considered on a common birth weight basis, showed that the males still took a significantly shorter time to reach the same pre-slaughter weight. The results set out in Table IV. further clearly support this contention. The finding that the actual rate of growth is greater with the male lambs is not in agreement with Bonsma, however, who claims that the difference in the rate of growth of males and females can be attributed to differences in birth weight. Bonsma's comparisons were made on Merino and first cross Merino lambs, however, and at a much younger age than the lambs of the present experiment.

Finally, the comparatively poor results shown by the twin lambs calls for some comment. In all 37 twin lambs were ear-tagged and weighed. Their average birth weight was 6.4 lbs. and of these only seven (less than 20 per cent.) reared as twins were marketed. They were of poor quality and took an average of 154 days to reach a suitable pre-slaughter weight. It is obvious that such lambs are of little value where export considerations are paramount, although "un-finished" lambs of this type can later be sold on the local market, and it might be therefore argued that two lambs are better than one. The remarks made with respect to single lambs, however, on the importance of exploiting any possibilities of increasing the birth weights and the subsequent growth rates apply with even greater force in the case of twins. The supplementary feeding supplied to the

ewes in the present experiment, although sufficient greatly to reduce losses of both ewes and lambs, was apparently not of sufficient quantity or quality to affect the birth weights or growth rates of either the twins or the singles. An experiment designed to test the effect of a much higher level of feeding is at present under way.

SUMMARY.

An experiment with 300 Border Leicester x Merino ewes, mated to Southdown rams, designed to test the value of a small supplement of wheaten grain ($\frac{1}{2}$ lb. per head per day) during the last four to six weeks of pregnancy, on the birth weight, growth rate and quality of the lamb is described.

No effect on the birth weight, growth rate, or quality of either the single or twin lambs was found, but the grain supplement significantly reduced the losses of ewes from pregnancy toxaemia and of lambs at or near lambing time, compared with the losses in the group receiving no such supplement.

The heavier lambs at birth were found to grow faster than the lighter. On the average each increase of 1 lb. in the birth weight reduced the time taken to reach a live weight of 65-70 lbs. by approximately one week.

A comparison of the birth weight and growth rate figures with other recordings for lambs of similar breeding is made. The conclusion is reached that the experimental ewes were capable of improved milk supply and of producing lambs of considerably heavier birth weight, resulting in a greatly increased growth rate of the lambs. The possibility that better grazing conditions or heavier supplementary feeding prior to lambing than that used in this experiment may be of great practical importance in this regard is discussed.

The male lambs were found to be approximately 7 per cent. heavier at birth than the females and actually grew faster than the females even when considered on the same birth weight basis.

A number of external carcase measurements were made and their significance discussed.

ACKNOWLEDGMENTS.

Grateful acknowledgment is made to the management of the W.A. Meat Export Cov., for their co-operation and to Messrs. T. J. Robinson, H. G. Cariss, W. Human, and H. Webb, of the Department of Agriculture, for their assistance at various stages of the investigation.

REFERENCES.

Bonsma, F. N. (1939), *Univ. Pret., S.A.*, Public. Series 1, Agric. 48.

Hammond, J. (1932), Growth and Development of Mutton Qualities in Sheep.

Pálsson, H. (1939 and 1940), *Jn. Agric. Sc.*, 29 : 544 & 30 : 1.

Shier, F. L., and Davenport, N. (1936), *Jn. Dept. Agric., W.A.* 13 : 260.

Sutton, G. L. Thomas, I., and Davenport, N. (1934), *Ibid* 11 : 355.

Thomson, W. and Fraser, A. H. H. (1939), *Scottish J. Agric.* 22 : 71.

Toop, C. R. (1941), *Jn. Dept. Agric., W.A.*, 18 : 142.

Underwood, E. J., Beck, A. B., and Shier, F. L. (1939), *Austral. J. Exp. Biol.* 17:183.

Underwood, E. J., and Shier, F. L. (1941), *Jn. Dept. Agric., W.A.* 18 : 13.

Underwood, E. J., Shier, F. L., and Harvey, R. J. (1937), *Ibid* 14 : 442.

Verges, J. B. (1939), *Suffolk Sheep Soc., Yr. Bk.*, 1939.

Rabbit Destruction.

A. ARNOLD, Chief Inspector of Rabbits.

There are various agencies employed in keeping rabbits in subjection, and different methods and activities are undertaken in separate localities in accordance with local conditions. But of all the agencies the poison cart is most universally used, as it enables an abundance of baits to be laid mechanically, whereas most other poisoning methods require hand work.

The main poisoning season commences with the drying up of the green feed, and those who have started operations, and who have been using the poison cart, are now finding that they are unable to procure phosphorus preparations so essential for its use.

Phosphorus plays a vital part in manufacture of certain parts of aeroplane engines, and as the local manufacturers of rabbit poison had ample stocks on hand for the current season's requirements, war conditions demanded that such stocks be frozen and appropriated for the more urgent need, and as fresh supplies are very uncertain, other poisons must be employed extensively in lieu of phosphorus if the rabbit pest is to be kept in satisfactory subjection.

Rabbit destruction falls under the following headings, poisoning, fumigating, digging out or digging in, and trapping.

POISONING.

In the absence of phosphorus, which is one of the most effective and economic poisons, it will be now necessary to use either strychnine, arsenic, or cyanide.

Strychnine is a good poison and and one of the most deadly baits that can be offered to rabbits. It is, however, a most bitter poison, and for this reason it is desirable to free feed for a few nights before laying the poisoned baits. It can be used successfully with oats and wheat with the addition of molasses to disguise the taste and make it more palatable, or with carrots, apples or quinces sweetened with either sugar or saccharine, it can also be used with grain.

When used with apples, carrots, quinces, etc., free feeding with unpoisoned bait for a few nights is essential to success. Strychnine is more costly than other poisons but is most deadly and effective, and I understand that at present there is no likelihood of a shortage of this material.

Arsenic is readily procurable, but is variable in its action, and on account of this is not looked upon as favourably as strychnine. Although cheap it is not as economical as strychnine when judged by results. It can be used in a similar manner to, and can be substituted for, strychnine.

Cyanide can be effectively used for poisoning water, and is extensively used in the drier parts of the State, where waters are scarce. It will yield excellent results. I have seen over 4,000 dead rabbits taken from around a dam after a night's poisoning.

Full instructions regarding free feeding and the use of grain and other methods than phosphorised pollards are given in the departmental pamphlet No. 57 on Vermin Destruction, which gives recipes and instruction on the various methods generally adopted in destroying rabbits.

One feature I cannot too strongly stress is the necessity for laying abundance of baits. Most vermin boards call for four miles of baits to be laid per 1,000 acres. It is noted that some landholders put down five miles of baits, laying them just

inside the boundary fence. This practice will not yield results. To be of any use poison needs to be laid *on the feeding grounds*, and here an abundance of baits should be put down. They should be laid in furrows, a number of which should be made about two chains apart, and where seven such furrows have been made it has been noted that baits have been taken from each, and more from the seventh furrow away from the boundary than the first. I cannot stress this point too strongly, and more especially in view of the fact that from now on baits will be mostly laid by hand, with the possibility of laying too little.

It is not advisable to substitute arsenic or strychnine for mixing with pollard in lieu of phosphorus. These poisons are indestructible and therefore remain poisonous for all time, and as pollard baits resemble Meggit's Nuts, it is obvious such baits would be poisonous for stock as long as they were allowed to remain. One reason why phosphorus poisoned baits are so universally used in Australia is that the phosphorus quickly oxidises, rendering the bait innocuous to stock a week or so after being laid.

Although the poison cart cannot be used to lay these baits mechanically, it can be availed of for the making of the furrows, and it is possible to lay either poisoned grain or apples by letting such bait fall into the furrow per medium of a piece of down pipe or some such contrivance.

FUMIGATION.

This, of course, can only be employed where burrows exist, and there are various fumigants and methods employed. The most efficient are the chemical materials that are known to give off a definitely poisonous gas, and of these carbon bi-sulphide and cyanide preparations are the most effective.

DIGGING OUT OR DIGGING IN.

Digging in and digging out appears to be a simple matter, but it requires care, it is easy to miss little runs or side burrows. This, however, entails labour which is costly and scarce just now, but the destruction of the burrows is no doubt "the" thing in rabbit destruction, and there is considerable truth in the axiom, "Aim at the rabbit and you miss him, aim at his cover and you hit him, place him on the surface and he cannot live." If warrens exist destroy them. A good dam sinking plough behind a tractor will do good work breaking the ground up to a reasonable depth, and making the surface loose to prevent the rabbits from digging out, and thus trapping all inside, and should any openings be found later these should be dealt with.

In cleared and open country the dealing with the warrens should be the method to employ. Where there is adjacent cover, poisoning should be undertaken, but whatever method is employed, no matter how successful, there is always a percentage of vermin left, therefore operations should be followed up by other means.

TRAPPING.

Trapping has its place in the scheme of destruction. It, however, tends to scatter the pest and causes them to clear out and find temporary lodgements elsewhere, only to come back later, and because of this it should be avoided. With judicious free feeding and poisoning it is possible to make a clean sweep, which is impossible with trapping. Consequently, trapping is not recommended by the Department, except as a mopping up process, and then only after other methods and not before.

The Bathurst Burr.

A SERIOUS NOXIOUS WEED INTRODUCED WITH STOCK.

C. A. Gardner, Government Botanist.

Bathurst Burr (*Xanthium spinosum L.*), one of the most serious weeds of Australia, which costs this country several thousands of pounds annually for its control, has recently appeared in several localities in Western Australia, the burrs having been introduced with imported sheep. This burr, which is about half an inch long, is provided with numerous fine hooked spines which firmly attach it to wool and hair, and thus it is well adapted for dispersal by animals. Its introduction from South America, its original home, was made about 1845 by horses said to have been introduced from Valparaiso into the Bathurst district, hence its local common name. The burrs were found in the tails of these horses.

Once established at Bathurst, it spread rapidly, and it is regarded as a serious weed, second only in importance to Prickly Pear. During the last forty or fifty years it has spread into every State of the Commonwealth, and despite the most rigid control, it succeeds in gaining a footing periodically in such places as ports of entry, stock and sale yards, or in places where stock rest in transit. The Western Australian Government has spent considerable sums of money in destroying the weed in such places as Kalgoorlie and Robb's Jetty—both of them places where stock are introduced from outside, but occasionally it appears also on the private holdings for which the stock are destined. Sheep carry the burrs in their wool, but since these are not always evident in a general inspection, it is necessary for farmers and pastoralists introducing sheep from places outside Western Australia, to carefully examine their sheep, and to keep a close watch for the plants which may appear subsequent to such importations.

The appearance of Bathurst burr at several country centres is causing the department some concern, for sometimes the burr is not reported or discovered until two or three years after its introduction, by which time it has usually established itself. As with other hardy annual weeds, once established, destruction becomes an undertaking which increases in difficulty from year to year. The plant seeds very freely, and will grow in almost any type of soil, and, furthermore, is capable of producing burrs when quite young. It is of seasonal duration only, and thus it is of the utmost importance that early recognition be made in order that destruction can be carried out immediately.

From the point of view of destruction, there is one feature that makes the work very difficult. Each burr contains two seeds; these are not liberated from the burr, but remain within the tough walls of the burr itself. One of the seeds usually germinates in the year, and when the plants are eradicated, the burr with its remaining fertile seed often remains in the soil, and the second seed may not germinate for several years, so that it is necessary to keep a watch over the area for from five to seven years. If one or two plants grow and produce burrs, sheep or other animals may collect these burrs in their feet or hair, wool, etc., and carry them far and wide. The presence of the burr greatly depreciates the value of wool.

Bathurst burr is a proclaimed noxious weed for the State of Western Australia, so that it is an offence against the Noxious Weeds Act to have the plant present on land under one's control. Bearing in mind the seriousness of the problems involved with some of our noxious weeds, and that failure to recognise them when they first appear, or neglect in early action, has resulted in some of these weeds getting out of control, it is the duty of every farmer and stockowner, in both his own, and the State's interest, to act promptly in these matters.

RECOGNITION AND CONTROL.

The weed is an annual plant with greenish-yellow stems, with three-pronged spines situated at the bases of the dark dull green leaves. The flowers are inconspicuous, and are succeeded by brown egg-shaped burrs which are almost woody.

Bathurst Burr (*Xanthium spinosum* L.).
Explanation of Plate.
A—Portion of branch with lateral branchlets. B—Young leaf and spines. C—Fruit or "burr."

and covered with fine hooked bristles; in addition, the burr itself has two short straight horns at its apex. The accompanying plate will help in recognition. Any suspected specimens should be collected, pressed, and forwarded to the Government Botanist, State Herbarium, Perth, for determination.

It is important that the plant should be prevented from forming the burrs. This can be done before flowering by either pulling it out, or cutting at the soil level. It is advisable to burn the plants as soon as sufficiently dry for the purpose. If the burrs are ripe, extreme care should be taken in order that they are not dropped in the process of collection and burning, and any loose burrs should be collected and destroyed.

Although Bathurst burr has a wide reputation as a weed, many people are still ignorant of it, and those who are introducing stock should carefully study the accompanying plate, and keep a close watch for the plant in the present and coming seasons.

Remembering the adage "One year's seeding makes many years' weeding," and that those weeds which to-day are considered beyond control could have been easily dealt with had they but been recognised when they first appeared, let us have some enthusiasm in the matter of weed suppression. It is unpardonable that weeds should be allowed to spread through neglect. Surely it is a small matter to have any strange plant identified, and prompt recognition has in many cases resulted in the complete destruction of weeds that, had they been neglected in their early stages of infestation, might have become major problems.

The history of wild turnip, cape tulip, and the doublegee, should serve as a lesson. It is in the interest of every local authority, and every farmer, to take an interest in every alien plant that comes under his notice. It may be something of no importance, but on the other hand it may be a serious menace.

The Inoculation of New Zealand Lupins in Relation to Green Manuring Practice.

by

W. P. Cass Smith, Plant Pathologist.

The urgent need for conserving nitrogenous fertilisers such as sulphate of ammonia and nitrate of soda, and for utilising existing supplies to the best possible advantage, has been emphasised in many quarters since the war commenced.

It has been pointed out that considerable economies can be effected in the use of such manures by growing where practicable *inoculated* leguminous crops, e.g. peas, tick beans, lupins, etc., and by either feeding these crops off *in situ*, or turning them under the soil. In the light of more recent happenings the part played by leguminous crops in building up and maintaining soil fertility has assumed even greater importance, and orchardists, market gardeners, and home gardeners alike, will probably have to rely more and more on the practice of green manuring with legumes if soil nitrogen is to be maintained at a sufficiently high level for crop or garden plant production. Unless the roots of such crops are inoculated with *effective* strains of nodule bacteria, the net gain in soil nitrogen content is little if any greater than would accrue from the growing of cereals, grasses, and other non-legumes (1).

When inoculated with effective strains of bacteria, however, the quantity of nitrogen fixed from the air by a leguminous crop is considerable. Thus, in an experiment conducted locally (2) it was estimated that the green yield

of a plot of Tangier peas inoculated with an effective strain of bacteria was twenty tons per acre, and that this amount contained the equivalent in terms of nitrogen of approximately 9 cwts. of sulphate of ammonia. On the other hand, the green yield of a non-inoculated plot was estimated at only five tons per acre containing the equivalent in terms of nitrogen of only $2\frac{1}{4}$ cwts. of sulphate of ammonia. Also, if both of these crops had been ploughed under the bulk of the nitrogen contained in the inoculated crop would have represented a net gain to the soil, whereas in the latter case little if any gain would have resulted as the non-inoculated crop largely utilised the available nitrogen in the soil for its growth.

Fortunately, the need for inoculating leguminous seeds prior to planting is now well recognised by farmers in Western Australia. Since 1926, when a bacterial culture service to farmers was inaugurated by the Department of Agriculture, spectacular results have been obtained in many areas following the planting of inoculated seed in new land, or in land in which similar legumes have not been grown previously. In the absence of effective inoculation, however, crop failures have frequently occurred.

Some of the strains of nodule forming bacteria available from this Department for seed inoculation purposes were isolated originally from the roots of locally grown legumes, while others have been obtained from England, Canada, America, South Australia and elsewhere.

For the inoculation of lupin seeds only one strain has hitherto been available to farmers, and this was isolated from the roots of the W.A. blue lupin (*Lupinus varius*), as inoculum for seeds of this species has formerly been in greatest demand. During the year 1940 doubt was expressed by some farmers concerning the effectiveness of this strain for the inoculation of New Zealand lupins (*L. angustifolius*). One farmer stated that even when planted in soil which previously had grown heavy crops of W.A. blue lupins for some years, and which therefore presumably contained ample supplies of the necessary nodule forming bacteria, the growth of New Zealand lupins was very poor.

New Zealand lupins are very suitable for green manuring, as they are easily turned in and subsequently rot quickly in the ground; furthermore, they produce a large bulk, yields of 15-20 tons per acre of green material being common in this State. In view of their excellence for this purpose and the probability that green manure crops must be increasingly grown in the near future, the isolation of a new effective strain specifically for the inoculation of New Zealand lupins was deemed to be an urgent matter. A number of isolations were therefore made from the roots of outstandingly healthy New Zealand lupin plants, and the nodule forming organisms were grown in pure culture.

Subsequently two of these isolates were selected and their effectiveness for the inoculation of New Zealand lupins was compared with the W.A. blue lupin strain of bacteria as described in the following experiment.

DETAILS OF EXPERIMENT.

The experiment was conducted at Pickering Brook at the property of Mr. Ray C. Owen, to whom the author's thanks are tendered.

Just prior to commencing the experiment the land was cleared of natural vegetation, which consisted mainly of jarrah and banksia, together with a little redgum; the area was then ploughed to a depth of four inches and harrowed twice to give a good seedbed. The soil which is typical of large areas in the Darling Ranges, consisted of ironstone gravelly sands varying from grey brown to light brown in colour at the surface.

TREATMENTS, LAYOUT, ETC.

The experiment consisting of four treatments, was arranged in random block form with five separately randomised replications of each treatment.

Treatments were as follows:—

Treatment (1) New Zealand lupin seed not inoculated.

Treatment (2) New Zealand lupin seed inoculated prior to planting with new isolate (a).

Treatment (3) New Zealand lupin seed inoculated prior to planting with new isolate (b).

Treatment (4) New Zealand lupin seed inoculated prior to planting with W.A. blue lupin strain of bacteria.

Treatment rows were half a chain long and four links apart and each row was hoed out to a depth of three inches and supered at the rate of three cwts. per acre just prior to planting. The seed, an ordinary commercial sample, was sown on the 4/6/41 at the rate of thirty-three seeds per row, the soil being quite moist at this time. The inoculation of the seed was carried out on the 3/6/41 in accordance with departmental recommendations.

NEW ZEALAND LUPIN INOCULATION EXPERIMENT.
SEASON 1941.

Note vigorous growth of lupins inoculated with a new and very effective strain of nodule-forming bacteria, and in contrast the generally stunted, unhealthy appearance of lupins either uninoculated, or inoculated with less effective strains. The green yield of the effectively inoculated plants was approximately 16 times that of the uninoculated "control" plants.
(Photo. by author.)

RESULTS.

On the 8/8/41 the experiment was inspected and treatment (2) in each of the five blocks was conspicuous by the greater height and more vigorous appearance of the plants, and the darker green colour of the foliage. In contrast, the plants in the remaining treatment rows were stunted and sickly in appearance, the foliage being reddish brown in colour, indicating nitrogen starvation. Subsequently the growth of plants in treatments (1) and (3) declined more and more and numbers of plants died out. A few plants in the rows of treatment (4), however, made fairly good growth late in the season, having apparently benefited from a delayed inoculation. As the season advanced, however, the differences in growth

in favour of treatment (2) became more and more marked, these plants being noticeably larger, darker green in colour and generally more vigorous in appearance than the plants in the remaining treatments even when viewed from a considerable distance away (see plate).

Harvesting was carried out on the 4 11 41 during the flowering stage by cutting off at ground level and weighing, fifteen plants selected at random from each treatment row.

Taking the green yield of the non-inoculated plants as 100 per cent. the percentage green yields for all treatments were as follows:—

Treatment (1) Seed not inoculated	100%
Treatment (2) Seed inoculated with new isolate (a)	1,581%
Treatment (3) Seed inoculated with new isolate (b)	113%
Treatment (4) Seed inoculated with W.A. blue lupin strain of nodule forming bacteria	158%

After the completion of harvesting numbers of plants were dug from each treatment row and their root systems were carefully examined. On the root systems of the plants from treatment (2) the bacterial nodules were aggregated around the main root in the form of a continuous sheath, and in marked contrast the plants from treatments (3) and (4) possessed nodules which were often quite large but confined to the lateral rootlets only. Nodules on the non inoculated plants were very few and when present were also confined to lateral rootlets.

Allen and Baldwin (3) have found that the occurrence of nodules on the tap root is a feature by which efficient strains may be recognised and thus their work receives confirmation from this experiment.

CONCLUSIONS.

From the green yield percentages it will be seen that New Zealand lupins inoculated prior to planting with a new strain of nodule forming bacteria (treatment 2) yielded approximately sixteen times the green weight of the non-inoculated plants (treatment 1), and ten times the green weight of plants inoculated with the W.A. blue lupin strain of bacteria. When considered in relation to green manuring practice, especially at the present time, the benefits to be derived from effective inoculation are very considerable, for not only may the yield of valuable humus forming compounds be greatly increased, but soil nitrogen may also be raised to a much higher level.

Thus assuming equal percentages of nitrogen in the green material from both the inoculated and uninoculated plants in this experiment, it is obvious when greater yield is considered that New Zealand lupins inoculated with an effective strain of bacteria (treatment 2) contained approximately sixteen times as much nitrogen as the uninoculated plants (treatment 1). Also if ploughed under, the bulk of the nitrogen contained in the inoculated plants, having been fixed from the air during growth by bacterial action, would represent a complete gain to the soil, whereas the uninoculated plants would merely be returning to the soil the nitrogen borrowed temporarily during growth.

In the above comparisons it has been assumed that the inoculated and uninoculated New Zealand lupins contained equal percentages of nitrogen. Frequently, however, legumes inoculated with an effective strain of bacteria contain much higher percentages of nitrogen than either uninoculated plants or those inoculated with a less effective strain.

For example in an experiment conducted at Ridge Hill in 1938 it was found that the dry matter of W.A. blue lupins inoculated with the appropriate strain of bacteria contained 3.83 per cent. nitrogen, compared with 1.89 per cent. nitrogen in the dry matter of the uninoculated plants. In this instance, however, there was no difference between the green yields of either lot (4).

Thus it is reasonable to assume that the percentage yield of nitrogen in the inoculated New Zealand lupins (treatment 2) would be at least as great as that of the uninoculated plants (treatment 1).

In future, therefore, this new and effective strain of bacteria will be propagated in the laboratory and pure cultures will be obtainable at the usual prices from the Plant Pathologist of the Department of Agriculture.

All growers and home-gardeners who contemplate planting New Zealand lupins for green manuring or for other purposes are strongly advised to inoculate the seed prior to planting, especially if crops of this species have not hitherto been successfully grown in the same soil.

Literature Cited.

(1) Cass-Smith, W. P.: "Conserve Nitrogenous Fertilisers by Growing Inoculated Legumes," *Journ. Dept. Agr.* W.A., 2nd Series, 18: 87-89, 1941.

(2) ———— "The Inoculation of Tangier Peas," *Journ. Dept. Agr.* W.A. 2nd Series, 15: 36-39, 1938.

(3) Allen, O. N., and Baldwin, I. L.: "The effectiveness of Rhizobia as influenced by Passage through the Host Plant," Agric. Expt. Station, Univ. of Wisconsin, Res. Bull. 106, 1-56, 1931.

(4) Cass-Smith, W. P., and Pittman, H. A. J.: "The effect of Inoculation on the Growth of Field Peas, Lucerne, Lupins and Tick Beans," *Journ. Dept. Agr.* 2nd Series, 16: 73-79, 1939.

Flax Rust.

By W. P. CASS SMITH, Plant Pathologist.

Small areas of flax and linseed have been grown in many parts of Western Australia during the last 30 years, but cultivation on a large scale for commercial purposes has only been attempted since the present war commenced.

The call for increased local production of both flax and linseed met with a ready response from farmers in this State and approximately 6,200 acres and 1,700 acres were planted to these crops respectively during the 1941 season.

Flax and linseed belong to the same botanical species (*Linum usitatissimum*), and both crops are susceptible to the same diseases, many of which may be transmitted by the seed or by infected straw carried with the seed.

As a precautionary measure, therefore, all seed for flax or linseed growing imported into Western Australia during the last two seasons by either the State or Commonwealth Governments, was carefully cleaned and treated with an organic mercury dust under departmental supervision prior to despatch to farmers.

In August, 1941, specimen linseed plants (tentatively identified by Mr. H. G. Elliott, Agrostologist, as Blue Riga) badly affected with flax rust were submitted to the Agricultural Department from the Northam area. Subsequently the crop from which these specimens were obtained was inspected, when it was seen that the disease was present in epidemic form and in consequence little, if any, seed would be harvested.

The disease had also spread to adjacent crops of Punjab linseed on this farm, but this variety was not so badly attacked.

It was ascertained that the severely affected crop of Blue Riga was the second crop originating from a line of commercial seed purchased locally in 1940. Prior to planting, the seed had neither been cleaned nor dusted with an organic mercury dust in either year, and both crops had been grown on the same land.

As a bag of the commercial seed was still on hand a careful examination was made and it was noticed that the seed was heavily contaminated with rust-laden fragments of straw and chaff (see Plate I).

There is little doubt, therefore, that flax rust was introduced on to this farm with the commercial seed in 1940, but owing to a very dry season the crop in that year was only slightly affected, and thus the disease escaped notice. However, in 1941, a year of more than average rainfall, an epidemic of flax rust developed following the planting on the same land of seed retained from the previous season's crop.

Plate 1.

Cleaned and non-cleaned samples of linseed. On left sample of a commercial line of Blue Riga, heavily contaminated with rust-laden fragments of straw and chaff, some of which are shown at left foreground. The sowing of this line of seed was followed by an epidemic of flax rust which completely ruined the yield of grain. Flax rust is not transmitted by infected seed, but rather with the seed by means of rust-infected fragments of straw and chaff. The necessity for thoroughly cleaning all seed prior to sowing is therefore obvious. Note on right, sample of Punjab linseed as distributed to contract growers. Under departmental supervision, all seed of this variety (and of the fibre varieties also) was thoroughly cleaned, and dusted with an organic mercury dust, prior to dispatch to contract growers.

(Photo by Government Photographer.)

The grave danger of introducing flax rust into a district by the planting of such contaminated lines of seed, and the necessity for rotating with other crops, will later be more obvious (see sections dealing with life cycle and control measures).

Subsequently the disease appeared in practically all linseed crops in the Northam and adjacent areas, but on the whole damage was only slight. At a later date rust was also discovered in trace in crops of fibre flax in certain south-western districts, including the Wokalup, Preston Valley, Donnybrook, Harvey and Yarloop areas.

With only limited local experience it is difficult to forecast accurately the extent to which flax rust is likely to menace the success of flax and linseed production in Western Australia. However, as both flax and linseed are planted here in the winter months, it seems unlikely that the disease will assume such serious proportions in this State as in European countries or the United States of America where spring planting is the rule.

Plate 2.

Portions of flax stems affected with the telcutospore stage of flax rust. The blackened areas (telcutosori) have a hard, crust-like, slightly raised surface and they are very noticeable on the stems in marked contrast to the golden colour of the healthy stem tissue. Under favourable conditions for its development, flax rust considerably lowers the yield of seed crops, but even light infections may cause serious damage to fibre varieties by discolouring and weakening the fibres and thus reducing fibre quality.

(Photo by Government Photographer.)

Nevertheless in view of the damage which flax rust often causes in other parts of the world, and here also when climatic conditions and very susceptible varieties favour its development, all growers should be conversant with the main symptoms, and the control measures which are necessary to reduce the disease to a minimum.

Occurrence.

Flax rust caused by the fungus *Melampsora lini* occurs in all the major flax-producing areas of the world. The disease has also been recorded from all States of the Commonwealth with the possible exception of Queensland. In Western Australia flax rust was first reported in 1931, when a small plot of flax grown in the East Pingelly district was badly affected. Since then the disease has not been noticed here until the 1941 season.

Symptoms.

The first indication of flax rust is the appearance in late winter or spring of orange coloured pustules which may occur on the stems, foliage or floral parts. At first the pustules are few in number and rather inconspicuous, but with moist weather conditions the pustules become more abundant until finally the whole crop may appear orange in hue. With dry, unfavourable conditions, however, little spread of the disease occurs, and in these circumstances affected plants are most noticeable in very thick or low lying portions of the crop. On closer examination the pustules are seen to be raised above the surrounding surfaces, and to be covered with an orange powdery mass, which is easily brushed off.

Later in the season as the crop is approaching maturity the colour of the pustules gradually changes to black. The blackened areas have a hard, crust-like, slightly raised surface, and they are particularly noticeable on the stems in marked contrast to the golden colour of the healthy stem tissue. (See plates 2 and 3.)

Damage from Flax Rust.

Under favourable conditions for its development, flax rust seriously lowers the yield of seed crops, but even light infections may cause severe damage to fibre varieties by discolouring and weakening the fibres and thus reducing fibre quality.

If the disease develops while the plants are still young the pustules may increase enormously in numbers, resulting in serious injury, whereas if the plants are nearing maturity when first attacked, the spread of the disease is limited.

Plate 3.

Flax seed bolls, and terminal branches, affected with the teleutospore stage of flax rust.

(Photo by Government Photographer.)

Life Cycle of Flax Rust.

Unlike the fungus causing stem rust of cereals (*Puccinia graminis*), which requires the presence of the common barberry (*Berberis vulgaris*) as an alternate host for the development of its complete life cycle, the flax rust organism is capable of passing through its whole life history on the flax plant.

The powdery material which is produced at each of the orange coloured pustules consists of numerous minute spores or fungal seeds (uredospores) of the flax rust parasite. The uredospores are widely disseminated through the agency of wind, rain, etc., and some eventually lodge on other healthy flax plants, where in the presence of moisture they germinate and may cause fresh pustules.

Each generation of spores requires about ten days to develop and with favourable climatic conditions, i.e., wet or humid weather, successive generations may be produced leading to the general distribution of rust throughout the crop.

When walking through a badly affected crop, the clothing becomes covered with the orange spore material, and clouds of spores rise which may be transported great distances by air currents, thus possibly leading to the infection of other crops.

Later in the season as the plants mature, the orange colour of the pustules gradually changes to black, due to the production of blackish spores of a different kind (teleutospores).

The teleutospores are resting spores which serve to carry the parasite over from one season to the next. During the following winter the teleutospores germinate to produce secondary spores and if these come in contact with a growing crop of flax or linseed, infection may occur leading to the reappearance once more of the orange pustules.

Flax rust is not transmitted by means of infected seed as are some other diseases of flax and linseed, e.g., browning (*Polyspora lini*) and wilt (*Fusarium lini*), but rather with the seed by means of rust infected straw or chaff. It has been shown by various workers*† elsewhere that when fragments of stems, leaves, or floral parts affected with the black teleutospore stage of the flax rust parasite are sown with the seed, the disease may develop in the following crop.

It is obvious, therefore, that by sowing improperly cleaned seed (and unfortunately commercial samples are frequently included in this category) the grower takes the risk of introducing flax rust into his district with the possibility of causing serious economic losses.

Host range and varietal susceptibility.

The parasite causing flax rust is only capable of attacking cultivated and "wild flax."

In this State two species of "wild flax" occur, namely *Linum marginale* and *Linum gallicum*. The former, an indigenous species, is widely distributed throughout the South-West, whereas *L. gallicum*, an introduced species, is limited mainly to the Vasse district.

Flax rust has been reported on *L. marginale* in most of the eastern States of Australia, but it was not until recently when the writer examined a number of "wild flax" specimens from the State Herbarium that typical symptoms of flax rust were discovered on a local plant of this species. This specimen was collected in the Wagin district in 1920 by the Government Botanist, Mr. C. A. Gardner, and as far as can be ascertained this constitutes the first definite record of the disease on "wild flax" in Western Australia. In view of the widespread occurrence of *L. marginale*, and also owing to the fact that cultivated flax has been grown here from time to time in so many districts, it is rather surprising that flax rust has not hitherto been reported on this species. It is possible, however, that rust is more prevalent on *L. marginale* than has hitherto been imagined. However, a careful survey must be made before this can be definitely determined.

---

*Pethybridge, G. H., and Lafferty, H. A.—Investigations on flax diseases. *Jour. Dept. Agr.*, Ireland. 20 : 334-337, 1920.

†Henry, A. W.—Flax rust and its control. *Minn. Agr. Exp. Sta. Tech. Bul.*, 36 : pp. 3-20, 1926.

Varieties of both flax and linseed differ considerably in their reactions to the flax rust parasite, varying from extremely susceptible to highly resistant. Observations last season indicated the following varietal reactions to the disease, listed in order of decreasing susceptibility: (1) Blue Riga; (2) Punjab; (3) Concurrent and Liral Crown; (4) Bison; (5) Ottawa.

The greater susceptibility of Blue Riga compared with Punjab was demonstrated in an interesting manner last season at the farm where flax rust was first reported.

Plate 4.

Varieties of both flax and linseed differ considerably in their reactions to flax rust. Note on right plants of the very susceptible Blue Riga variety which are blackened by the teleutospore stage of the disease, and very stunted in growth. Note on left plants of the Punjab variety which developed as admixtures in the crop of Blue Riga and which are affected much less seriously by the disease.

(Photo by Government Photographer.)

After completing the sowing of one paddock with Punjab, the grower without cleaning out the drill commenced to sow an adjacent paddock with the Blue Riga variety with the result that numerous Punjab plants developed as admixtures

throughout the Blue Riga crop. Subsequently it was very evident that plants of the Blue Riga variety were almost completely blackened by the teleutospore stage of the disease, very stunted and largely defoliated, whereas the Punjab plants were relatively much healthier in appearance. (Plate 4.)

Control Measures.

Resistant varieties.—Undoubtedly the best means of controlling flax rust is by the growing of highly resistant or immune varieties of satisfactory quality. However, the breeding of such varieties suitable for local conditions is a task presenting certain difficulties. The organism causing flax rust is a highly specialised parasite which collectively comprises a number of physiological races. Thus a variety of flax or linseed which is highly resistant to one race of the causal fungus may be very susceptible to another race.

It follows, therefore, that all races of flax rust present locally must be accurately identified before the breeding of rust resistant varieties can be undertaken with any certainty of success.

Flor‡ has shown that more than 20 races of flax rust exist in the United States of America, and Waterhouse and Watson§ who are investigating this important matter in Australia have recently determined that one race of the flax rust organism which is common to New South Wales, Victoria, South Australia and Tasmania is distinct from any of the races recorded to date in other parts of the world.

These Australian studies are being continued by the above two workers and the Department of Agriculture is co-operating by forwarding to them representative specimens of flax rust in the orange uredospore stage.

Growers, schoolteachers and others interested, can assist considerably in this valuable work by making collections of the uredospore stage of the rust on both cultivated and "wild flax" and forwarding them to the writer.

From observations made last season it would appear that the varieties of fibre and linseed flax grown here were only slightly affected, not because they are highly resistant, but rather because of early planting which enabled crops to escape more serious damage from the disease. Until varieties of proved resistance are introduced, therefore, other measures should be adopted to reduce to a minimum damage from flax rust.

Stubble Burn and Rotation.—Since the flax rust parasite persists from one season to the next on infected straw or chaff, a thorough stubble burn prior to the sowing of the crop will assist considerably in the control of the disease. Also for this reason a rotation with other crops should be adopted if at all feasible, so that neither flax nor linseed are grown again on the same land for a year or two.

Crop rotation is also a valuable means of keeping in check other serious diseases of flax and linseed.

Clean Seed and Seed Disinfection.—All seed should be thoroughly graded and cleaned to remove foreign matter and the screenings should be burned. Fragments of straw and chaff which are usually present in non-cleaned seed may be affected with rust and other diseases and these are transmitted to the following crop when

‡Flor, H. H.—New Physiologic Races of Flax Rust. *Jour. Agr. Res.*, 60 : 575-591, 1940.

§Waterhouse, W. L., and Watson, I. A.—A note on determinations of physiological specialisation in flax rust. *Jour. & Proc. Roy. Soc.*, N.S.W., 75 : 115-117, 1941.

non-cleaned seed is sown. The cleaning of commercial lines of seed of unknown origin is especially important, for otherwise these may be the means of introducing new races of flax rust or entirely new diseases with serious consequences.

As some diseases of flax, e.g., browning (traces of which were noticed last season) may be carried by the seed, the additional precaution should be taken of disinfecting all seed with an organic mercury dust. Ceresan or Agrosan applied at the rate of three to four ounces per bushel are recommended for this purpose.

Owing to the poisonous nature of both these substances the precautions specified by the manufacturers, and printed on the containers, should be observed when handling either the dusts, or disinfected seed.

Arrangements have been made whereby all seed issued to contract growers for this year's cropping will again be cleaned and dusted prior to despatch.

Time of Seeding.—When crops are attacked by rust at an early stage of growth the yield of either seed or good quality fibre may be seriously reduced. On the other hand if rust does not develop until crops are approaching maturity the losses may be very slight only. For this reason seeding should take place as early as possible within the correct period for each district so that crops are well forward in growth when liability to rust commences in the spring.

According to the Government Entomologist liability to losses from climbing cutworms and other seed attacking insects is also reduced when crops are planted early in the season.

Government Certified Subterranean Clover Seed.

Areas suitable for the production of Government certified subterranean clover seed during the 1941–42 season have been registered for the following producers :—

Early (Dwalganup) strain—

D. Bradford	Narrogin
E. Farleigh	Boyup Brook
P. D. Forrest	Boyup Brook
Fowler Bros.	Narrogin
L. W. Moore	Benjinup
O. R. Vallentine	Beverley
S. L. Walters	Cranbrook

Midseason strain—

L. Busquets	Elgin
E. Farleigh	Boyup Brook
Fowler Bros.	Narrogin
L. W. Moore	Benjinup
Summerlea Pastoral Co.	Capel

Purchasers are reminded, however, that the registration of areas is only a preliminary stage and the seed is not Government certified unless the sack bears the official seal and the strain certification tag.

Oat Grazing and Recovery Trial—Avondale Research Station.

I. Thomas, Superintendent of Wheat Farming, and
A. J. Millington, Field Technician.

Until recent years, it has been usual to evaluate oat varieties on their ability to yield either grain or hay or as dual purpose varieties. The development of the fat lamb industry has created a demand for early green grazing, which can be supplied in most years by oats sown on fallow. As natural pasture becomes available it is not unusual to remove the sheep from the crop and use it either for grain or hay. Some feeding off is also desirable in particular seasons to reduce excessive rankness, with consequent poor quality hay or harvesting difficulties.

Small scale cutting and recovery trials at the Wongan Hills and Avondale Research Stations have shown that varieties differ appreciably in their ability to produce early green feed and satisfactory grain yields after cutting.

The management of cereals for grazing and recovery is based on an appreciation of the different stages or phases in the development of the plant. The first stage above ground is the development of foliage leaves which are the site of manufacture and to some extent, storage, of food material used for aerial and particularly root growth. About the base of the plant a number of buds are formed, each of which carries at its apex the minute cells from which the ear and seeds develop. The second phase comprises the elongation of the base of each bud to give a stalk carrying the ear. The removal of the ear bearing shoots seriously reduces the grain yield, so that the aim in management is to confine grazing to the leafy vegetative phase and to avoid the injury of reproductive shoots.

During 1941 the small scale cutting trials were extended to include an actual field grazing and recovery trial at Avondale, embracing the varieties Fulghum, Dale (W. 3), Ballidu (W. 2), Wongan and Mulga. The plot yields were assessed by cutting and weighing quadrats from each. After sampling, the plots were heavily grazed by sheep to a uniform sward in a period of three days.

The experiment was sown on typical York gum-jam country which had been fallowed during the previous spring. Seed and superphosphate were applied at the rate of 60 lbs. and 112 lbs. per acre respectively. Sown in late April, germination was almost immediate and although only 1,327 points were recorded for the year, 1,108 fell in the growing period, constituting a good season.

Table I.

AVONDALE RESEARCH STATION.

Rainfall for 1941.

Jan.	Feb.	Mar.	Apl.	For Growing Period.						Nov.	Dec.	Total for year.
				May.	June.	July.	Aug.	Sept.	Oct.			
	1	12	151	165	446	205	154	111	27	35	20	1,327

The first grazing, on 23rd June, was delayed a week by unfavourable weather and this resulted in the very early maturing variety Wongan being more advanced than was desirable. At the time of grazing the variety Fulghum had attained a height of about 8 in. and the other varieties 12 in.

The plots were again sampled on 24th July, and then heavily and quickly grazed.

The detailed results of the experiment are given in Table II., where they are expressed on a moisture-free basis. To obtain the yields as hay weights would require the addition of about 10 per cent.

Table II.

Variety.	First Cutting, 23–6–41.	Second Cutting, 24–7–41.	Total.	Grain Yields per acre.
	cwt. per acre.	cwt. per acre.	cwt. per acre.	bus. lb.
Fulghum	6·05	7·80	13·85	10 32
Wongan	6·44	6·47	12·91	4 12
Ballidu	6·09	6·68	12·77	8 6
Dale	5·80	7·04	12·84	7 0
Mulga	5·67	5·99	11·66	2 23
Signif. Diff. (P = ·05)	0·42	0·58	0·67	1 21

Apart from Fulghum, the varieties under test may be classed as general purpose oats, not particularly well adapted to grazing, since the leafy vegetative phase is of relatively short duration and they are easily killed by over-grazing. Fulghum, on the other hand, will withstand heavier and longer grazing, but in view of its particularly weak straw will require feeding off if it is used either for hay or grain.

The variety of Fulghum is of American origin and early midseason maturity. When subjected to moderate grazing it yields hay of good quality, whilst the grain is light cream in colour and of intermediate quality. For grazing and recovery, it generally gives satisfactory results with less management than the popular general purpose oats.

Although the most widely grown early maturing oat in Western Australia, Mulga is apt to yield rather coarse hay when growth is rank and to lodge if left for grain. As the above results indicate, it was the poorest of the oats under test for grazing and recovery and is particularly sensitive to over-grazing. Taken in conjunction with other trials, the indications are that the capacity of Mulga is usually one early grazing.

Ballidu (W. 2) is also an early maturing oat developed at the Wongan Hills Research Station from a cross between Mulga and Burt's Early. It is of superior straw strength, yields hay of better quality, has given greater grain yields and, as the above figures indicate, is a better oat for grazing and recovery than Mulga, which it equals in grain quality.

Intermediate between Guyra and Algerian in maturity, the variety Dale is of the same origin as Ballidu. It promises to meet satisfactorily the demand for an oat slightly earlier than Algerian, and of better straw strength than Guyra.

The variety Wongan grows vigorously in the juvenile stages, and whilst a useful source of early winter feed, it must be grazed early if the subsequent grain yields are not to be unduly depressed.

The success or otherwise of the use of cereals for grazing and recovery depends largely on the management and the season. Generally, sowings will be made early on either fallow or stubble, prior to the opening rains, and in consequence weed growth must be controlled by grazing heavily at first to ensure uniform feeding off of weeds and the more palatable cereals. This will make the use of small paddocks or the temporary subdivision of large ones advantageous, particularly as growth is seldom uniform over a large paddock, with the result that the most rank growth is grazed least.

The high nutritive value of young green oats is clearly shown by the protein content of material from this experiment, given in Table III., on a dry matter basis. No varietal differences in palatability could be discerned.

TABLE III.

Variety.	Percentage Crude Protein.		Percentage Crude Fibre.		Percentage Carbohydrates.	
	23–6–41.	24–7–41.	23–6–41.	24–7–41.	23–7–41.	24–7–41.
Wongan	23·9	21·1	24·1	24·6	35·3	39·7
Fulghum	28·1	21·6	20·5	22·1	33·1	39·8
Mulga	25·5	23·0	21·2	22·6	36·1	38·8
Ballidu	24·2	22·2	20·6	22·1	35·5	41·6
Dale	25·1	23·6	20·4	21·2	34·5	39·6
Good Cereal Hay ...	5%		30%		57%	

Wheat and Oat Variety Trials—1941.

I. THOMAS, Superintendent of Wheat Farming, and
A. J. MILLINGTON, Field Technician.

Variety trials are conducted annually with wheat and oats at the research stations, and apart from the hereunder published tables, the department has available much data relating to the relative yielding ability of new and standard varieties. Plantings are made according to the maturity of the varieties under test.

Except at the Chapman and Salmon Gums Research Station, where rust resistance is a factor, Bencubbin replaced Nabawa as the control variety, since it consistently outyields that variety. The continued superiority of the Bencubbin yields no doubt accounts for its being the most extensively grown variety in Australia; no less than 30 per cent. of the Western Australian and 22 per cent. of the Australian acreages being sown to it.

Rust resistant varieties are of great interest at the Chapman Research Station, where the very resistant variety Fedweb, has consistently outyielded Nabawa over the past four years. Additional varieties introduced last year from New South Wales, were the Eureka I. and II. wheats, which derive their resistance from a Kenya crossbred.

Satisfactory yields have been recorded by the very early maturing variety Bungulla, which was developed to replace Noongaar, and like that variety must not

be sown before the last week of May. Earlier planting will result in rank growth or tangled crops, particularly on light land.

Although handsome premiums are at times paid for the "strong" flour varieties, such as Pusa IV. and Comeback, it is evident from the accompanying table that Bencubbin will usually outyield them by a considerable margin.

The new early maturing, stout strawed variety, Koorda, has satisfactorily completed its trials for yielding ability and disease resistance. It is anticipated that it will replace Ghyas Early, Totadgin, and Merredin for later plantings, particularly on the lighter soil types. Intermediate in maturity between Nabawa and the parent Sutton, W.4 promises to be a useful variety for early midseason plantings and as in the case of Koorda, its superior straw strength will be very valuable on sandy soils in the better rainfall areas.

Of interest in the oat trials are the satisfactory yields recorded by the new varieties, Dale and Ballidu. The former is a late midseason and the latter an early maturing variety, but both are derived from a (Mulga × Burt's Early) cross and are notable for their straw strength. It is expected that Dale will replace Guyra and to some extent Algerian whilst Ballidu promises to be a much better grazing and general purpose oat than Mulga. The variety Algeribee does not appear to be notably superior to Algerian.

In connection with the accompanying results of wheat variety trials, those at Merredin and Wongan Hills were planted in the middle of each month and germinated at the end of the same months. At the other three stations the trials were divided into two sections, early maturing and late maturing varieties, both to be sown in May with approximately at least a fortnight between plantings. Seasonal conditions affect the germinating date; trials at Salmon Gums were actually planted early and late in May, but did not germinate until mid-June; the late planting at Avondale was also much slower in germinating than the early planting. Due to circumstances, those at Chapman were unfortunately not planted until the first half of June. Experiments conducted for many years have shown that the major plantings should be carried out in May with small sowings of the later maturing varieties in late April and of the very early varieties in early June.

Oat Variety Trials at Merredin and Wongan Hills Research Stations during 1941.

Variety.	MERREDIN RESEARCH STATION.					WONGAN HILLS RESEARCH STATION.				
	1941 Season.			Average to end of 1938.*		1941 Season.			Average to end of 1940.	
	Yield per acre.	Yield per acre adjacent Guyra Control.	Percentage of the Control.	No. of Years.	Percentage of the Mulga Control.	Yield per acre.	Yield per acre adjacent Guyra Control.	Percentage of the Control.	No. of Years.	Percentage of the Burt's Early Control.
	bus. lb.	bus. lb.	%		%	bus. lb.	bus. lb.	%		%
Algerian	....	....	....	....	....	22 17	21 16	105	11	116
Algeribee	....	....	....	....	....	23 32	21 16	111	1	86
Burt's Early	....	....	....	....	....	17 16	20 3	86	Control	
Guyra	Control		100	7	93	Control		100	11	107
Mulga	42 24	43 0	99	Control		16 27	19 18	86	11	93
Palestine	....	....	....	5	95	....	....	....	4	110
Parkers	....	....	....	....	....	2 11	20 33	11	1	35
Wongan	44 0	43 0	102	2	73	13 27	20 3	68	5	114
Ballidu	50 32	42 24	119	1	104	23 18	19 18	120	1	97
Dale	39 32	42 24	93	....	....	19 6	20 33	92	3	123
	Planted on 7th May. Germinated on 17th May.					Planted on 28th May. Germinated on 8th June.				

*No results in 1939 due to storm damage and in 1940 due to drought.

Wheat Seasonal Variety Trials conducted on Research Stations during 1941.

Variety.	CHAPMAN RESEARCH STATION.						AVONDALE RESEARCH STATION.						SALMON GUMS RESEARCH STATION.					
	1941 Season.			Average for period ending 1941.			1941 Season.			Average for period ending 1940.			1941 Season.			Average for period ending 1941.		
	Germination date.	Yield per acre.	Yield per acre adjacent Nabawa Control.	Percentage of the Control.	No. of Years.	Percentage of Nabawa Control.	Germination date.	Yield per acre.	Yield per acre adjacent Benecubbin Control.	Percentage of the Control.	No. of Years.	Percentage of Nabawa Control.	Germination date.	Yield per acre.	Yield per acre adjacent Nabawa Control.	Percentage of the Control.	No. of Years.	Percentage of Nabawa Control.
		bus. lb.	bus. lb.	%		%		bus. lb.	bus. lb.	%		%		bus. lb.	bus. lb.	%		%
Benecubbin	June 12	12 43	11 12	114	5	117	May 9	....	Control	100	2	112	June 16	10 46	8 42	124	2	115
Bungulla	June 23	16 43	13 47	121	3	113	June 15	19 12	19 6	100	....	...	June 16	9 58	10 20	96	2	102
Eureka I.	June 23	14 19	13 47	104	....	....	....	....	..	.	.	.	....	. .	. .	.	....	..
Eureka II. ...	June 12	12 48	11 28	114	....	...	....	....	..	.	.	.	....	. .	. .	.	....	..
Fedweb	June 12	11 28	11 12	102	4	104	May 9	16 3	19 38	82	2	109	June 16	9 30	10 30	90	2	90
Ford ...	June 12	13 12	11 9	118	5	101	....	..	...	....	2	106	June 16	8 22	8 42	96	2	90
Ghyas Early ...	....	....	....	....	....	....	....	....	....	....	....	..	June 16	9 56	10 20	96	....	..
Merredin	June 23	15 4	13 44	110	3	102	June 15	19 53	19 18	103	....	....	June 16	8 48	9 58	90	2	97
Koorda	June 23	14 58	13 44	106	4	114	June 15	17 22	19 18	90	2	109	June 16	9 46	9 58	98	2	97
Nabawa	June 12	Control	variety	100		100	May 9	15 16	19 38	78	Control	10	June 16	Control		100		100
Sutton	June 12	10 45	11 46	91	....	....	May 9	17 40	20 15	88	....	....	....	....	....	....	....	....
W. 4	June 12	12 38	11 46	107	4	107	May 9	18 4	20 15	89	2	118	June 16	9 36	10 30	91	2	91

Wheat Seasonal Variety Trials conducted on Research Stations during 1941.

Variety.	Planting and Germinating Month.	MERREDIN RESEARCH STATION.					WONGAN HILLS RESEARCH STATION.				
		1941 Season.			Average for period ending 1939.*		1941 Season.			Average for period ending 1940.	
		Varietal Yield per acre.	Yield per acre adjacent Bencubbin Control.	Percentage of Control.	No. of Yrs.	Percentage of the Nabawa Control.	Varietal Yield per acre.	Yield per acre adjacent Bencubbin Control.	Percentage of Control.	No. of Yrs.	Percentage of the Nabawa Control.
		bus. lb.	bus. lb.	%		%	bus. lb.	bus. lb.	%		%
Bencubbin	April	Control	....	100	10	113	Control	....	100	10	112
	May	Control	....	100	10	112	Control	....	100	10	112
	June	Control	....	100	9	114	Control	....	100	10	105
Bungulla	May	28 29	32 10	88	3	115	11 12	12 53	87	2	107
	June	....	....	....	3	131	20 43	19 26	107	2	90
Comeback	May	17 9	32 53	52	3	63	7 38	11 36	66	....	....
Fedweb	April	18 51	26 21	71	1	73	10 34	15 57	66	....	....
	May	....	....	....	....	....	8 29	11 39	73	2	98
Gluyas Early	May	21 46	31 5	69	11	108	10 29	12 53	81	10	95
	June	....	....	....	....	....	17 31	19 58	88	....	....
Merredin	May	27 4	31 2	87	....	....	10 48	12 41	85	10	91
	June	....	....	....	9	101	17 39	19 12	91	10	91
Koorda	May	25 41	31 2	83	3	98	10 35	12 41	83	3	107
	June	....	....	....	1	105	20 5	19 12	105	3	109
Nabawa	April	....	....	....	Control		11 49	15 57	74	Control	
	May	28 5	31 5	90	Control		10 27	11 39	90	Control	
Noongaar	May	29 14	32 10	91	11	104	....	....	....	....	....
	June	....	....	....	11	120	14 14	19 26	73	12	88
Pusa IV.	May	25 44	32 53	78	3	95	6 27	11 36	55	1	97
	June	....	....	....	....	....	17 9	19 58	85	....	....
Sutton	April	....	....	....	....	....	12 38	16 42	76	9	108
	May	....	....	....	....	....	10 0	11 23	88	7	97
W.4	April	24 3	26 21	91	....	....	14 21	16 42	86	2	113
	May	....	....	....	....	....	10 34	11 23	93	3	109

*No results in 1940 due to drought.

Contents.

		Page
EXPERIMENTS WITH MICRO-ELEMENTS FOR THE GROWTH OF CROPS IN WESTERN AUSTRALIA	A. S. Wild and L. J. H. Teakle	71
ARTHRITIS IN LAMBS	C. R. Toop	79
FARM MANURE	M. Cullity	81
GASCOYNE STOCK ROUTE POISON PLANTS	C. A. Gardner	84
COPPER DEFICIENCY OF CATTLE AND THE FATAL TERMINATION "FALLING DISEASE"	H. W. Bennetts	96
SOME POULTRY PESTS	C. F. H. Jenkins and P. N. Forte	104
PASTURE DEVELOPMENT—Part 1	H. G. Elliott and F. E. Ryan	116
Part 2	... ...	129

SANDBAGS
ARE GOOD SHELTER
AND SO ARE
SAVINGS!

Build slit trenches and air raid shelters by all means—but build your SAVINGS, too! The important thing to do is keep the enemy well away from our doors. The more money you save the greater protection you are building around your home . . . For the money you save helps to provide bombers, guns, essential equipment.

Don't spend foolishly—don't buy anything you don't really need—look after the pence, and watch the shillings and pounds as well. Before you know it, you will have saved a substantial sum to help AUSTRALIA TO VICTORY.

AN ACCOUNT WITH THE

COMMONWEALTH SAVINGS BANK

WILL SIMPLIFY SAVING.

2—4

Poultry Farmers and Storekeepers

Eggs are a vital and necessary food.

Prices are good and every Egg is wanted.

Make arrangements to consign all your Poultry Produce to—

T. NEWBY

Highest Returns Guaranteed

Egg boxes and Poultry crates on application

Sufficient Address---

T. NEWBY, Metropolitan Markets

Telephone B 7733

Please mention the *Journal of Agriculture, W.A.*, when writing to advertisers. 4—4